THE UNIVERSITY OF KANSAS

PALEONTOLOGICAL CONTRIBUTIONS

June 22, 1966 Paper 8

PERMIAN FUSULINIDS FROM SICILY

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ABSTRACT

The Permian of the Sosio Valley in Sicily consists of several exotic blocks of light-colored limestone entirely surrounded by, and partially buried in, Mesozoic and Tertiary rocks. Their geographic alignment suggests that they may have been brought to their present position by a large fault. Our material, collected from three of the blocks, includes one species, each, of *Boultonia, Schubertella, Yangchienia, Pseudofusulina, Schwagerina, Rugososchwagerina, Verbeekina,* and *Neoschwagerina,* two species of *Rauserella,* and three species of *Sosioella,* a new subgenus of *Chusenella.* In addition, it contains a new species of *Kahlerina,* a genus that has been classified by some specialists as a fusulinid and by others as an endothyrid.

INTRODUCTION

The classical exposures of Permian rocks in Sicily consist of four isolated blocks of massive, reeflike limestone, located in the valley of the Sosio River (Fig. 1) in the southern part of the province of Palermo. They are surrounded by, and partially embedded in, rocks of Mesozoic or Tertiary age. Their alignment suggests that they may have been brought to their present position by a large fault, though FABIANI (1925) expressed the belief that these blocks have been pushed up through the overlying less resistant Triassic beds along the axis of a tightly folded anticline. In any event, faulting, of one sort or another, appears to have been involved in their present placement.

The largest of the blocks, known as Pietra di Salomone, is about 200 m. long and 85 to 100 m. wide. On its north and northeast sides it rises in a cliff to a height of about 30 m., from which it slopes rather steeply southwestward and plunges into the Triassic deposits which surround it. According to FURNISH & GLENISTER (personal communication), "it represents a reef core composed of sponges and algae to a large extent. At one spot . . . the limestone is definitely stratified and composed of coarse detritus such as in a flank, just a short distance from the massive portion."

About 1,200 m. to the northwest is the Rupe del Passo di Burgio, smallest of the four blocks, originally about 12 m. long, 11 m. wide, and 6 m. high. According to FABIANI & RUIZ (1932), it has been nearly destroyed by fossil collectors.

A third block, the Rocca di San Benedetto, is located a little less than 1 km. to the north of the Rupe del Passo di Burgio. It consists of two parts, the larger of which rises like a tower to a height of about 25 m. The smaller part, located on the south side, is generally considered as belonging to the same block.

Finally, to the north-northwest of the Rocca di San Benedetto and lying between it and the stream of San Calogero, is a fourth block called the Rupe di San Calogero.

In addition to these better-known outcrops, FURNISH & GLENISTER stated (personal communication), "Additionally, there is a Wolfcampian limestone found as a small remnant near the railroad station at Roccapalumba. We did not visit the spot . . . but it is at a distance of some 25 km.

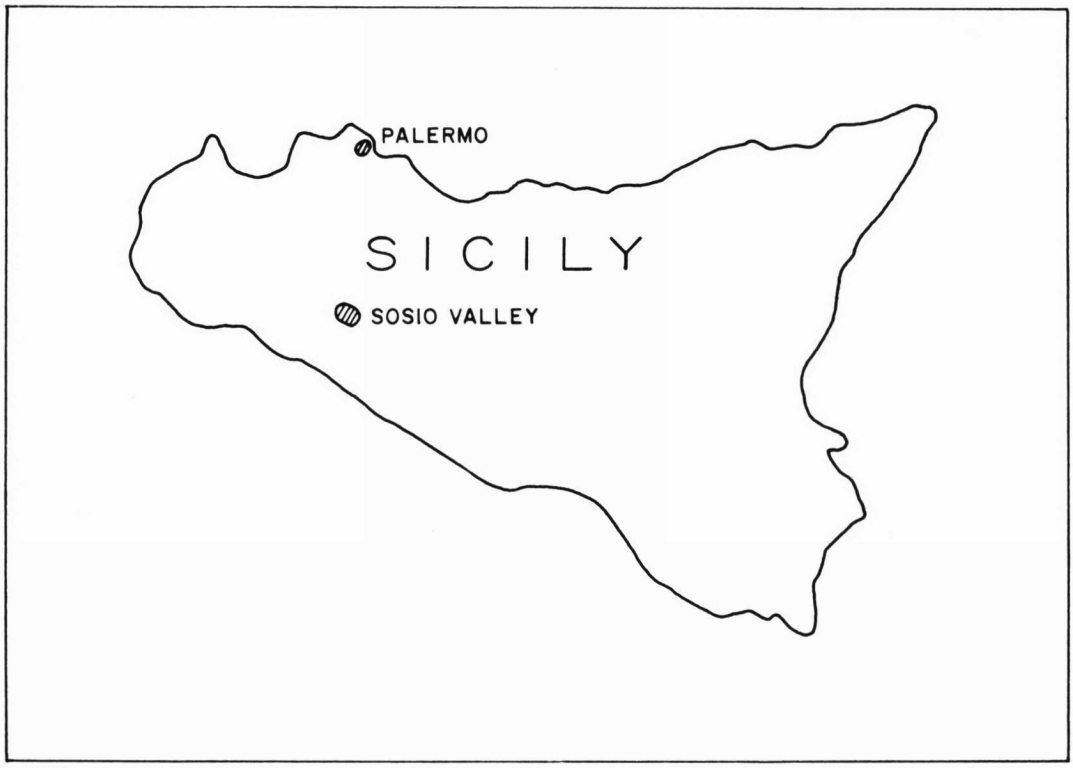


FIG. 1. Sketch map showing location of Sosio Valley.

from Salomone." We have no further information on this exposure.

The bulk of our material was collected by Dr. LEONARDO DAINELLI, of Geneva, Switzerland, from the Pietra di Salomone, Rocca di San Benedetto, and Rupe del Passo di Burgio, respectively. It consists of about 30 pounds of light cream-colored limestone which contains a profusion of algal remains. Fusulinids, on the other hand, are relatively scarce, a fact that is rather surprising, since previous publications have usually referred to this limestone as the "Calcari con *Fusulina*." In addition to Dr. DAINELLI's collections we have a few specimens, free of matrix, of *Rugososchwagerina yabei* (VON STAFF) which were presumably collected from the Rupe del Passo di Burgio and which were donated to us by Dr. CARL O. DUNBAR.

Finally, we have a fine suite of specimens sent to us by Dr. WILLIAM M. FURNISH and Dr. BRIAN F. GLENISTER. This material was collected by them in July, 1965, with the assistance of Mr. CLAUDE SPINOSA, a research assistant at the University of Iowa, and Dr. GIUSEPPE BUCCHERI, lecturer and curator of the Istituto e Museo di Geologia dell'Universita di Palermo. The work was carried out with the aid of NSF grant B-65, 371.

Most of these fossils came from the Pietra di Salomone and occur in several different types of lithology.

SILVESTRI (1932, 1933), in describing his material, spoke repeatedly of limestone "filled with" or "crammed full of" *"Schwagerina yabei."* Although this is supposedly the most common species in the Sosio Limestone, since SILVESTRI cited it as abundant in all four blocks, we have not found a single specimen in DAINELLI's collections. It is common, however, in one of the pieces of limestone collected by FURNISH and GLENISTER from the Pietra di Salomone. According to them (personal communication), this was a "slab found loose on the western slope of the biohermal mass. . . . Only a few other fusulinaceans were found in the chalky biohermal core of Salomone. All other specimens from that locality occur in the associated steeply dipping flank beds along the west-

ern margin." We are inclined to conclude that, with exception of a few scattered specimens, most fusulinids in this limestone occur in small patches or "pockets" and that these limited areas of abundance have been rather thoroughly depleted through the years by fossil collectors. It seems probable that if large fresh surfaces could be exposed, more of the local "pockets" of abundance would be found. This "patchy" accumulation of fossils is in keeping with the reeflike character of the rock.

There appears to be a definite association of certain fusulinid species with certain types of lithology. For example, all of our specimens of *Rugososchwagerina yabei* occur in a chalky, relatively soft, algal limestone which FURNISH and GLENISTER consider to be reef core. This is also true of *Chusenella (Sosioella)* SKINNER & WILDE, n. subgen., and *Yangchienia thompsoni* SKINNER & WILDE, n. sp. On the other hand, *Schwagerina dainellii* SKINNER & WILDE, n. sp., *Verbeekina furnishi* SKINNER & WILDE, n. sp., and *Neoschwagerina sosioensis* SKINNER & WILDE, n. sp., have been found only in the harder more crystalline, and slightly darker limestones which make up their "flank beds."

Although this has been a classical Permian fossil locality since GEMMELLARO (1887) first described a part of the fauna, we know of only four published papers in which Sicilian fusulinids were actually described.

VON STAFF (1909) described *Schwagerina yabei*, which was designated by MIKLUKHO-MAKLAY (1959) as the type species of *Rugososchwagerina*.

DE GREGORIO (1930) published descriptions of many Sosio fossils, including fusulinids, but his descriptions are so brief and illustrations so poor that his species cannot be recognized without a restudy of the type specimens.

SILVESTRI (1932) discussed the Sosio locality and listed many fossils which had been found there. Also, he included one plate showing five photographs of fusulinids, but he did not describe any species in this paper.

The following year SILVESTRI (1933) described and illustrated a number of species of fusulinids from the Sosio Limestone. Among them were *Rugososchwagerina yabei* (VON STAFF) and a new species of *Sumatrina* which he named *S. gemmellaroi*. The remainder of his specimens were assigned, incorrectly, to previously described species. One of the latter, which SILVESTRI referred to *Fusulinella bocki* VON MÖLLER, was later questionably referred to *Yangchienia tobleri* by THOMPSON (1935). Our material contains all species described by SILVESTRI with the exception of *Sumatrina gemmellaroi*. In addition, it contains two species of *Rauserella*, two species of *Chusenella (Sosioella)*, and one species, each, of *Pseudofusulina, Boultonia, Schubertella,* and *Kahlerina* which have not been previously reported from this locality.

PASINI (1964), working with eight specimens from SILVESTRI's collection, redescribed as *Chusenella sosioensis* the species which SILVESTRI had incorrectly assigned to *Fusulina prisca* (EHRENBERG).

Although the fusulinids of the Sosio Limestone have been largely neglected, other elements of the fauna have been studied intensively. Between 1887 and 1896 GEMMELLARO published a series of papers describing the cephalopods, gastropods, pelecypods, brachiopods, and crustaceans. Because of their value for interregional correlations the cephalopods have received the most attention from later workers. For example, MILLER (1933) published a paper in which the ammonoid fauna was compared in detail with Permian ammonoid faunas from other parts of the world. MILLER concluded that the Sosio Limestone is almost certainly correlative with a part of the lower Guadalupian of West Texas. The fusulinid fauna tends to confirm his conclusion.

In recent years a number of European and Japanese geologists have referred to beds of this age as the "Sosio Stage" of the Permian. Since it appears probable that the term will be more widely used in the future, it seems desirable to document the fusulinid fauna of this famous locality as well as the material at hand permits.

We wish to express thanks to our colleagues who have made this study possible by placing materials at our disposal and to the Humble Oil & Refining Company for permission to publish this paper. All of the figured specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

S-1.—Sosio Limestone. Loose specimens, presumably from the Rupe del Passo di Burgio. Donated by Dr. CARL O. DUNBAR.

S-2.—Sosio Limestone. Rocca di San Benedetto. Collected by Dr. LEONARDO DAINELLI.

S-3.—Sosio Limestone. Pietra di Salomone. Collected by Dr. LEONARDO DAINELLI.

S-4.—Sosio Limestone. Rupe del Passo di Burgio. Collected by Dr. LEONARDO DAINELLI. An interesting feature of this collection is the presence of dozens of immature specimens of *Propinacoceras*. The specimens usually have only two to two and one-half whorls, and are so small that they were thought, prior to sectioning, to be Foraminifera.

S-5.—Sosio Limestone. Pietra di Salomone. A single piece of white, relatively soft, chalky, algal limestone collected by FURNISH and GLENISTER as a loose slab "on the western slope of the biohermal mass." This contains a greater abundance of fusulinids than any other single piece of rock in our Sosio collections, and apparently came from the reef core.

S-6.—Sosio Limestone. Pietra di Salomone. Two small pieces of limestone similar in lithology to S-5. Collected by FURNISH and GLENISTER.

S-7.—Sosio Limestone. Pietra di Salomone. Cream to light tan, relatively hard, somewhat crystalline, fragmental limestone. Collected by FURNISH and GLENISTER from limestone which they consider as "flank beds."

SYSTEMATIC PALEONTOLOGY

Genus KAHLERINA Kochansky-Devidé & Ramovš, 1955

KAHLERINA SICILIANA Skinner & Wilde, n. sp.

Shell minute, thickly discoidal to subspherical, umbilicate, axis of coiling in shorter diameter. Mature specimens have 4 to 4.5 whorls, and measure 0.90 to 1.00 mm. in axial length, and 1.38 to 2.05 mm. in sagittal diameter. Form ratio varies from 0.46 to 0.65.

Spirotheca composed of very thin tectum and relatively thick inner layer which displays faintly visible alveolar structure and which is analogous to keriotheca of some fusulinids. In 4th volution thickness of spirotheca varies from 36 to 71 μ, averaging about 54 μ. In final 1 or 2 chambers of mature shell spirotheca thins abruptly and becomes very erratic in shape (Pl. 1, figs. *4-7*), even tending to uncoil, as in *Codonofusiella*. Septa are unfluted but convex anteriorly. They are thick throughout their length, becoming even thicker at basal margin, so that in sagittal sections they appear club-shaped (Pl. 1, figs. *4, 5*). They appear to be formed by simple inbending of spirotheca and to be composed of same elements as latter. Septa number 6 to 8 in 1st whorl, 7 to 8 in 2nd, 8 to 9 in 3rd, and about 10 in 4th. Large septal pores present, particularly in last 2 or 3 chambers (Pl. 1, fig. *6*).

Proloculus small, its outside diameter ranging from 114 to 161 μ. Tunnel low and wide, tunnel angle measuring 46 to 55 degrees in 4th volution. No chomata present, but in axial sections which coincide with septal plane low protuberances superficially resembling parachomata are present on floor of tunnel. [Authors of the genus interpreted these as parachomata and suggested that *Kahlerina* is allied to the verbeekinids. Examination of well-preserved specimens, however, reveals the structures to be remnants of the basal margins of the septa which were left intact after formation of the tunnel by coalescence of a row of large, elliptical pores (Pl. 1, fig. *1*; Pl. 2, fig. *1*).]

Discussion.—KOCHANSKY-DEVIDÉ & RAMOVŠ (1955) described *Kahlerina*, with *K. pachytheca* KOCHANSKY-DEVIDÉ & RAMOVŠ as type species, from the Middle Permian of the Julian Alps in northwestern Yugoslavia. It was associated with the genera *Boultonia, Rauserella, Schwagerina, Verbeekina, Neoschwagerina, Afghanella, Sumatrina,* and *Pseudodoliolina*. With exception of *Afghanella* and *Pseudodoliolina*, all of these genera are known to occur in the Sosio Limestone.

A few months later SOSNINA (1956) proposed the genus *Ussuriella*, with *U. ussurica* SOSNINA as the type species, from beds of similar age in southeastern Siberia. *Ussuriella* is obviously a synonym of *Kahlerina*. THOMPSON & MILLER (1935) figured a species of *Kahlerina* as *Endothyra?* sp. (pl. 79, figs. *8, 9*). Their specimens came from a black limestone believed to be part of the middle member of the Yanghsin Limestone on the eastern limb of the Omeishan anticline in Szechuan Province, China. They were associated with a species which THOMPSON & MILLER named

Schwagerina fosteri. Later, THOMPSON & FOSTER (1937) transferred this species to *Paraschwagerina*, and in the same paper described several verbeekinids and neoschwagerinids from the upper part of the Yanghsin Limestone in the same area. Still later, THOMPSON (1964) assigned *P. fosteri* to *Rugososchwagerina*. If this assignment is correct, it seems probable that the Chinese species of *Kahlerina* is of about the same age as the Sosio Limestone.

In addition, we have found a few specimens of *Kahlerina* associated with *Yabeina* at Akasaka, Japan, and the genus is common in the *Yabeina* and *Lepidolina* zones of the Cambodian Permian. Thus, it appears that *Kahlerina* ranges through most of the Middle and Upper Permian of southern Eurasia.

Kahlerina siciliana SKINNER & WILDE, n. sp., more closely resembles *K. pachytheca* KOCHANSKY-DEVIDÉ & RAMOVŠ than any other described species. It differs from the latter in its larger diameter, fewer whorls, smaller form ratio, and commonly larger proloculus. An interesting feature of our specimens is the fact that all of them are partially or wholly surrounded by an incrusting organism (Pl. 1, fig. *6*; Pl. 2, fig. *6*). In some cases this organism appears to have invaded the interior of the final chambers (Pl. 1, fig. *1*), and in one instance it has joined a shell of *K. siciliana* to that of a specimen of *Rauserella staffi* SKINNER & WILDE, n. sp. (Pl. 2, fig. *6*). It seems possible that this incrustation may have been initiated while the foraminifer was still alive, and that the erratic growth of the final chambers may have been a reaction to this process. It should be noted that the specimen of *Rauserella* cited above (Pl. 2, figs. *6*, *7*) displays a similar eccentricity in its terminal chambers, differing in this respect from a normal specimen (Pl. 2, figs. *4*, *5*).

Occurrence.—We have found this species in collection S-2, from the Rocca di San Benedetto, where it is associated with *Rauserella staffi* SKINNER & WILDE, n. sp., and *Chusenella (Sosioella) sosioensis* PASINI. Three specimens were found in collection S-5, from the Pietra di Salomone, where they were associated with *Chusenella (Sosioella) sosioensis* PASINI, *C. (S.) glenisteri* SKINNER & WILDE, n. sp., *C. (S.) intermedia* SKINNER & WILDE, n. sp., *Rugososchwagerina yabei* (VON STAFF), *Yangchienia thompsoni* SKINNER & WILDE, n. sp., and *Pseudofusulina anachrona* SKINNER & WILDE, n. sp.

Illustrations.—Plate 1, figures *1-7*; Plate 2, figure 1.——Pl. 1, fig. *1*. Axial section of holotype, ×40.——Pl. 1, fig. *2*. Axial section of paratype, ×40.——Pl. 1, fig. *3*. Slightly oblique axial section of paratype, ×40.——Pl. 1, figs. *4-6*. Sagittal sections of paratypes, ×40.——Pl. 1, fig. *7*. Parallel section of paratype just missing proloculus, ×40. [Note encrusting organism completely surrounding specimen in fig. 6.]——Pl. 2, fig. *1*. Part of holotype, ×100. Small protuberances on floor of tunnel are not parachomata but remnants of basal margins of septa which were left after large pores coalesced to form the tunnel. [All from collection S-2.] [All figures are unretouched photographs.]

Genus RAUSERELLA Dunbar, 1944

RAUSERELLA STAFFI Skinner & Wilde, n. sp.

Shell minute, irregularly subcylindrical, with bluntly rounded poles. Our only well-oriented axial section has 5 whorls, and measures 3.07 mm. in length, and 1.15 mm. in diameter. Form ratio is 2.67. First 2.5 to 3 whorls constitute a tightly coiled juvenarium lenticular in shape and with rather sharply rounded periphery. Its axis is shorter diameter and it is coiled askew to later, more loosely coiled volutions.

Spirotheca composed of thin tectum and thicker, structureless inner layer, with thickness varying from 13 to 20 μ in 4th whorl, and 29 to 32 μ in 5th. Septa unfluted and slightly convex anteriorly, appear to be formed by simple inbending of spirotheca and to be composed of same elements. They are thinner than spirotheca, however. Septa number 8 to 10 in 3rd volution, and about 8 in 4th. Large septal pores are present.

Proloculus minute, with outside diameter ranging from 68 to 75 μ. Tunnel cannot be measured in outer whorls of our axial section, but in 3rd volution tunnel angle varies from 16 to 20 degrees. Very weak chomata border tunnel in juvenarium, but are absent in adult stage.

Discussion.—*Rauserella staffi* is similar to *R. erratica* DUNBAR, from Las Delicias, Mexico. It differs from that species in its slightly larger size and less numerous septa. Although we have only three well-oriented specimens, one axial and two sagittal, we think that its stratigraphic signifi-

cance justifies giving it a formal name. The genus *Rauserella* is known to occur in the lower and upper Guadalupian of Mexico and western Texas, in North America, and in the *Verbeekina-Neoschwagerina* Zone of Japan and the *Lepidolina* Zone of Cambodia. Thus it appears to range through much of the Middle and Upper Permian. This species is named for Dr. HANS VON STAFF, who was the first to describe a fusulinid from the Sosio Limestone.

Occurrence.—We have found this species only in collection S-2, from the Rocca di San Benedetto, where it is associated with *Kahlerina siciliana* SKINNER & WILDE, n. sp., and *Chusenella (Sosioella) sosioensis* PASINI.

Illustrations.—Plate 2, figures *2-7.*——Figs. *2-3.* Axial section of holotype, ×20, ×40.——Figs. *4-5.* Sagittal section of paratype, ×20, ×40.——Fig. *6.* Sagittal section of paratype, which has been partially incrusted by an organism that has completely surrounded a specimen of *Kahlerina siciliana*, ×20. Latter is specimen shown in Pl. 1, fig. 7.——Fig. 7. Specimen shown in fig. *6*, ×40. [All from collection S-2.] [All figures are unretouched photographs.]

RAUSERELLA sp.

Shell minute, cylindrical, with bluntly rounded poles. Our single axial section has only 3.5 whorls, first 2 of which are discoidal in shape and coiled askew to more loosely coiled outer ones. It measures 1.16 mm. in length, and 0.51 mm. in diameter, giving form ratio of 2.27.

Spirotheca composed of thin outer tectum and thicker inner structureless layer, with thickness in 4th volution about 17 μ. Septa unfluted but convex anteriorly. They appear to be composed of same elements as spirotheca. Since we have no sagittal sections no septal count could be made.

Proloculus minute, not quite spherical, its outside diameter in our axial section measuring 76 by 79 μ. A very questionable measurement of the tunnel angle in 3rd volution is 42 degrees.

Discussion.—This is a very rare species in our material, only one axial and one parallel section having been found. It differs from *Rauserella staffi* SKINNER & WILDE, n. sp., in its much smaller size, smaller form ratio, more regular shape, and fewer whorls in the juvenarium.

Occurrence.—We have found *Rauserella* sp. only in collection S-4, from the Rupe del Passo di Burgio, where it is associated with *Boultonia* sp., *Schubertella silverstrii* SKINNER & WILDE, n. sp., and *Propinacoceras beyrichi* GEMMELLARO.

Illustrations.—Plate 3, figures *1-4.*——Figs. *1-2.* Axial section, ×40, ×100.——Figs. *3-4.* Parallel section, ×40, ×100. [Both from collection S-4.] [All figures are unretouched photographs.]

Genus BOULTONIA Lee, 1927

BOULTONIA sp.

Shell minute, fusiform, with sharply pointed poles. Our single axial section has 4.5 volutions, first 2 of which constitute tightly coiled, discoidal juvenarium which is coiled askew to later whorls. In our two sagittal sections numbers of whorls in juvenarium are 1 and 1.5, respectively. Axial section measures 0.96 mm. in length, and 0.41 mm. in diameter, giving form ratio of 2.34.

Spirotheca composed of thin tectum and thicker inner structureless layer, analogous to diaphanotheca of fusulinellids. In 5th volution its thickness is about 14 μ. Septa, composed of same elements as spirotheca, are nearly plane across middle of shell but become rather strongly fluted toward poles. They number 8 or 9 in 1st whorl, 9 to 14 in 2nd, 14 to 15 in 3rd, and 17 to 23 in 4th.

Proloculus minute, with outside diameter 32 to 43 μ. Tunnel low and moderately wide. Tunnel angle measures 21 degrees in 4th volution, and 47 degrees in 5th. Chomata rather massive for so small a shell, persisting into final whorl.

Discussion.—*Boultonia* sp. bears some resemblance to *B. cascadensis* THOMPSON, WHEELER, & DANNER, from the Morcrop Limestone of northwestern Washington. It differs from that species in its larger form ratio and slightly larger proloculus.

Occurrence.—We have found this species only in collection S-4, from the Rupe del Passo di Burgio, where it is associated with *Rauserella* sp., *Schubertella silvestrii* SKINNER & WILDE, n. sp., and *Propinacoceras beyrichi* GEMMELLARO.

Illustrations.—Plate 3, figures *5-11.*—Figs. *5-6.* Slightly oblique axial section, ×40, ×100.——Figs. *7-8.* Sagittal section, ×40, ×100.——Figs. *9-10.* Another sagittal section, ×40, ×100.——Fig. *11.* Tangential section, ×40. [All from collection S-4.] [All figures are unretouched photographs.]

Genus SCHUBERTELLA von Staff & Wedekind, 1910

SCHUBERTELLA SILVESTRII Skinner & Wilde, n. sp.

Shell minute, ellipsoidal, with bluntly rounded poles. None of our sections is truly axial, best ones being slightly oblique; consequently, measurements of axial length are only approximations and are slightly smaller than true length. Mature individuals have 4 to 4.5 whorls, measuring about 0.48 to 0.69 mm. in length, and 0.43 to 0.52 mm. in diameter. Form ratio varies from about 1.12 to 1.47. As in the measurements of length, these figures are a little too small. First 1.5 to 2 volutions discoidal and coiled askew to later ones.

Spirotheca composed of thin tectum and thicker inner structureless layer which is analogous to fusulinellid diaphanotheca. In 4th volution its thickness varies from 20 to 23 μ. Septa composed of same elements as spirotheca, and formed by simple inbending of latter. They are essentially plane and number about 7 in 1st whorl, 10 in 2nd, 12 in 3rd, and 14 in 4th.

Proloculus minute, its outside diameter varying from 40 to 49 μ. Tunnel low and moderately wide. Tunnel angle varies from 40 to 47 degrees in 4th whorl. Rather massive chomata border tunnel, even in final volution.

Discussion.—*Schubertella silvestrii* SKINNER & WILDE, n. sp., resembles *S. melonica* DUNBAR & SKINNER, from the Leonardian of West Texas, but it is only about one-half as large as the latter. We know of no other species with which it is likely to be confused. It is named for the late Dr. ALFREDO SILVESTRI.

Occurrence.—We have found this species only in collection S-4, from the Rupe del Passo di Burgio, where it is associated with *Boultonia* sp., *Rauserella* sp., and *Propinacoceras beyrichi* GEMMELLARO.

Illustrations.—Plate 4, figures *1-10.*——Fig. *1.* Slightly oblique axial section of holotype, ×40. ——Figs. *2-4.* Oblique sections of paratypes, ×40. ——Fig. *5.* Sagittal section of paratype, ×40.—— Figs. *6-10.* Specimens shown in 1-5, respectively, ×100. [All from collection S-4.] [All figures are unretouched photographs.]

Genus YANGCHIENIA Lee, 1933

YANGCHIENIA THOMPSONI Skinner & Wilde, n. sp.

Fusulinella bocki SILVESTRI, 1933, Mem. dell'Inst. Geol. della R. Univ. di Padova, v. 10, p. 31, 32, pl. 2, fig. 7, pl. 3, fig. 6.

Yangchienia tobleri THOMPSON *(partim),* 1935, Eclogae geol. Helvetiae, v. 28, p. 516, 517, pl. 17, figs. 1, 2 (*not* pl. 17, fig. 7).

Yangchienia tobleri THOMPSON, 1948, Univ. Kansas Paleont. Contrib., Protozoa, art. 1, pl. 5, figs. 5, 7.

Shell small, fusiform, with nearly straight lateral slopes and rather bluntly pointed poles. Mature specimens have 10 to 10.5 whorls, rarely 11, and measure 2.58 to 3.21 mm. in length, and 1.45 to 1.64 mm. in diameter. First 1 or 2 volutions are discoidal and coiled askew to the later ones. Form ratio varies from 1.58 to 1.96, averaging about 1.82.

Thin spirotheca composed of tectum and diaphanotheca; its thickness in 9th volution measuring 22 to 27 μ. Commonly a rather thick, darker layer is present inside diaphanotheca in equatorial region, but this is part of massive chomata deposits spreading across tops of chambers rather than a true inner tectorium. Septa plane throughout their length and composed of same elements as spirotheca. Diaphanotheca commonly extends down both anterior and posterior faces of septa. Septal pores are abundant, usually appearing as darker spots due to their having been plugged with secondary material. Septa number about 7 in 1st volution, about 13 in 2nd, 16 to 19 in 3rd, 17 to 21 in 4th, 19 to 24 in 5th, 22 to 26 in 6th, 26 to 27 in 7th, 29 to 31 in 8th, 30 to 33 in 9th, and about 32 in 10th.

Proloculus very small, its outside diameter varying from 46 to 101 μ, averaging about 69 μ. Tunnel narrow and high, tunnel angle in 10th whorl measuring 16 to 24 degrees. Massive chomata bordering tunnel are nearly vertical on side adjacent to it and extend with undiminished height for about 0.25 of distance toward poles, at which point they slope rather sharply and continue to poles with a greatly reduced height.

Discussion.—OZAWA & TOBLER (1929) briefly described as *Fusulinella* sp. a tangential section of a small fusulinid from the Island of Katakupho, Greece. It was associated with *Neoschwagerina* and a species which they described as *Sumatrina pesuliensis* OZAWA & TOBLER. SILVESTRI (1933) described and figured, from the Pietra di Salomone, a small species which he identified as *Fusulinella bocki* VON MÖLLER. This was rather disturbing to American specialists, for in this hemisphere *Fusulinella* is apparently restricted to

Middle Pennsylvanian rocks, whereas the associated Grecian and Sicilian faunas are unquestionably Permian.

THOMPSON (1935) redescribed the specimen from Katakupho as *Yangchienia tobleri* THOMPSON, designating the tangential section figured by OZAWA & TOBLER as the "type specimen." He referred SILVESTRI's specimens to this species with question. An examination of the photographs of *Sumatrina pesuliensis* leads to a strong suspicion that this species belongs in *Afghanella*, a genus commonly associated with *Yangchienia*, rather than in *Sumatrina*.

Although it is difficult to obtain a clear idea of the characters of *Yangchienia tobleri*, since the only specimen certainly assigned to it is represented by an incomplete tangential section, certain apparent differences exist between it and the Sosio species. The most obvious of these is the development of the chomata which, in *Y. tobleri* appear to extend with undiminished height nearly to the poles, whereas in *Y. thompsoni* the chomata display a marked reduction in height at about one-fourth of the distance from the tunnel to the poles. This reduction is particularly marked in the outer whorls. In addition, the lateral slopes of *Y. thompsoni* are straight or slightly concave, instead of convex as they appear to be in *Y. tobleri*. For these reasons we believe that the Grecian and Sicilian specimens are not conspecific.

Yangchienia thompsoni closely resembles *Y. haydeni* THOMPSON, from Afghanistan, but differs in its slightly smaller form ratio and narrower tunnel. It is named for Dr. M. L. THOMPSON.

Occurrence.—We have found this species only in collection S-5, from the Pietra di Salomone, where it is associated with *Rugososchwagerina yabei* (VON STAFF), *Chusenella (Sosioella) glenisteri* SKINNER & WILDE, n. sp., *C. (S.) sosioensis* PASINI, *C. (S.) intermedia* SKINNER & WILDE, n. sp., and *Pseudofusulina anachrona* SKINNER & WILDE, n. sp.

Illustrations.—Plate 4, figures *11-12*; Plate 5, figures *1-10*; Plate 6, figures *1-4*.——Pl. 4, figs. *11-12*. Axial section of holotype, ×10, ×20.——Pl. 5, fig. *1*. Axial section of holotype, ×40.——Pl. 5, figs. *2-8*. Axial sections of paratypes, ×20.——Pl. 5, figs. *9-10*. Sagittal sections of paratypes, ×20.——Pl. 6, fig. *1*. Sagittal section of paratype, ×20.——Pl. 6, fig. *2*. Part of holotype, ×100.——Pl. 6, figs. *3-4*. Parts of paratype shown in Pl. 5, fig. 10, ×100. [Note that chomata deposits are built of alternating layers of lighter and darker material.] [All from collection S-5.] [All figures are unretouched photographs.]

Genus PSEUDOFUSULINA Dunbar & Skinner, 1931

[emend. SKINNER & WILDE, 1965]

PSEUDOFUSULINA ANACHRONA Skinner & Wilde, n. sp.

Shell rather large, elongate, subcylindrical, with bluntly pointed poles. Mature individuals have 5.5 to 6.5 whorls, and measure 9.50 to 10.90 mm. in length and 2.09 to 2.76 mm. in diameter. Form ratio varies from 4.19 to 4.54.

Spirotheca composed of tectum and coarsely alveolar keriotheca, with thickness in 5th volution 107 to 127 microns. It displays moderate "rugosity," consisting of sharp indentations of tectum (Pl. 7, fig. *4*). Septa strongly but irregularly folded from pole to pole. In our only sagittal

EXPLANATIONS OF PLATES

Plate 1, figures 1-7. *Kahlerina siciliana* SKINNER & WILDE, n. sp. (p. 4).

Plate 2, figure 1. *Kahlerina siciliana* (p. 4); figures 2-7, *Rauserella staffi* SKINNNER & WILDE, n. sp. (p. 5).

Plate 3, figures 1-4, *Rauserella* sp. (p. 6); figures 5-11, *Boultonia* sp. (p. 6).

Plate 4, figures 1-10, *Schubertella silvestrii* SKINNER & WILDE, n. sp. (p. 6); figures 11-12, *Yangchienia thompsoni* SKINNER & WILDE, n. sp. (p. 7).

Plate 5, figures 1-10, *Yangchienia thompsoni* (p. 7).

Plate 6, figures 1-4, *Yangchienia thompsoni* (p. 7); figure 5, *Pseudofusulina anachrona* SKINNER & WILDE, n. sp. (p. 8).

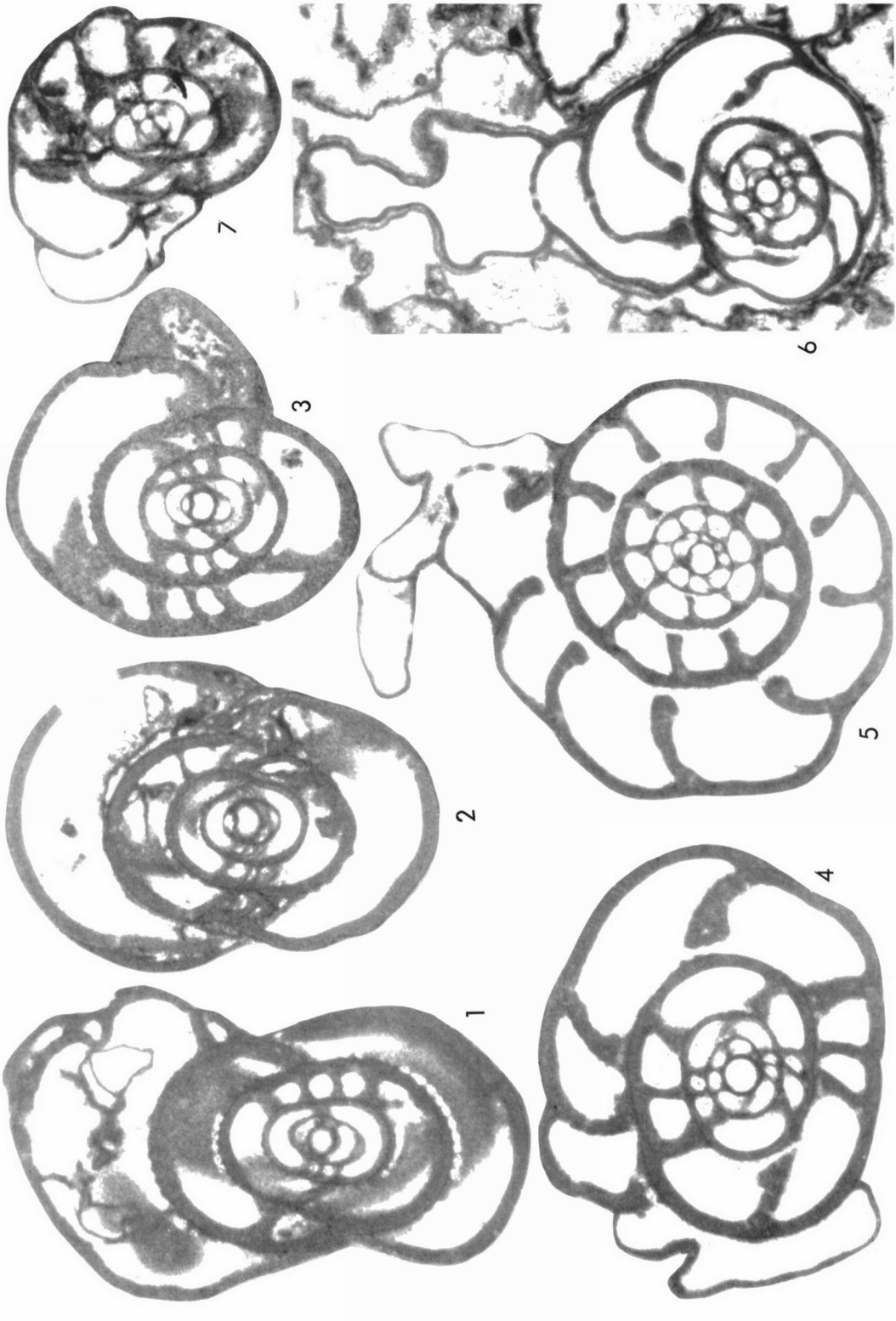
Plate 7, figures 1-5, *Pseudofusulina anachrona* (p. 8).

Plate 8, figures 1-4, *Schwagerina dainellii* SKINNER & WILDE, n. sp. (p. 9).

Plate 9, figures 1-4, *Schwagerina dainellii* (p. 9).

Plate 10, figures 1-3, *Chusenella (Sosioella) sosioensis* SKINNER & WILDE, n. sp. (p. 11).

[For explanation of Plates 11-20, see page 9.]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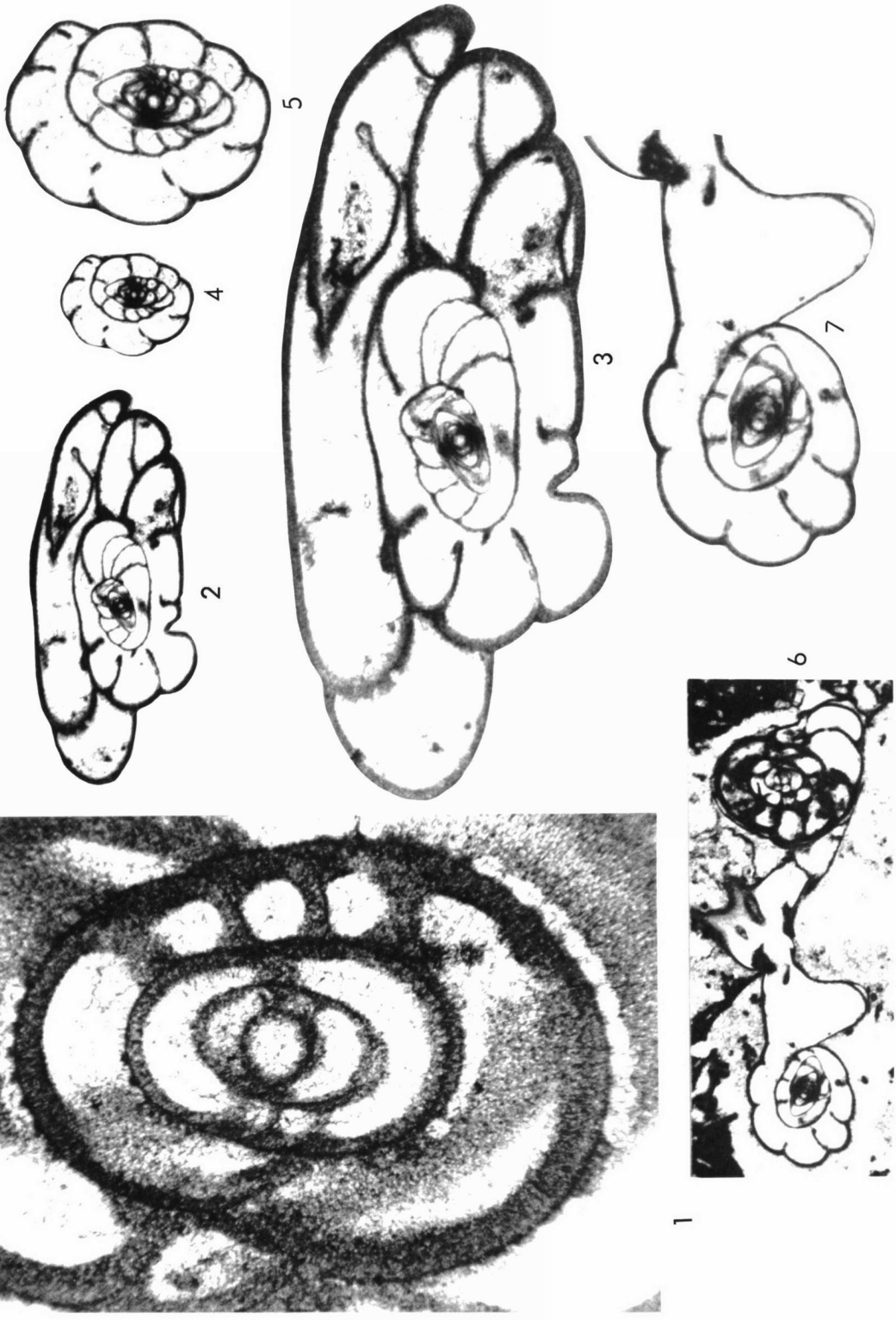
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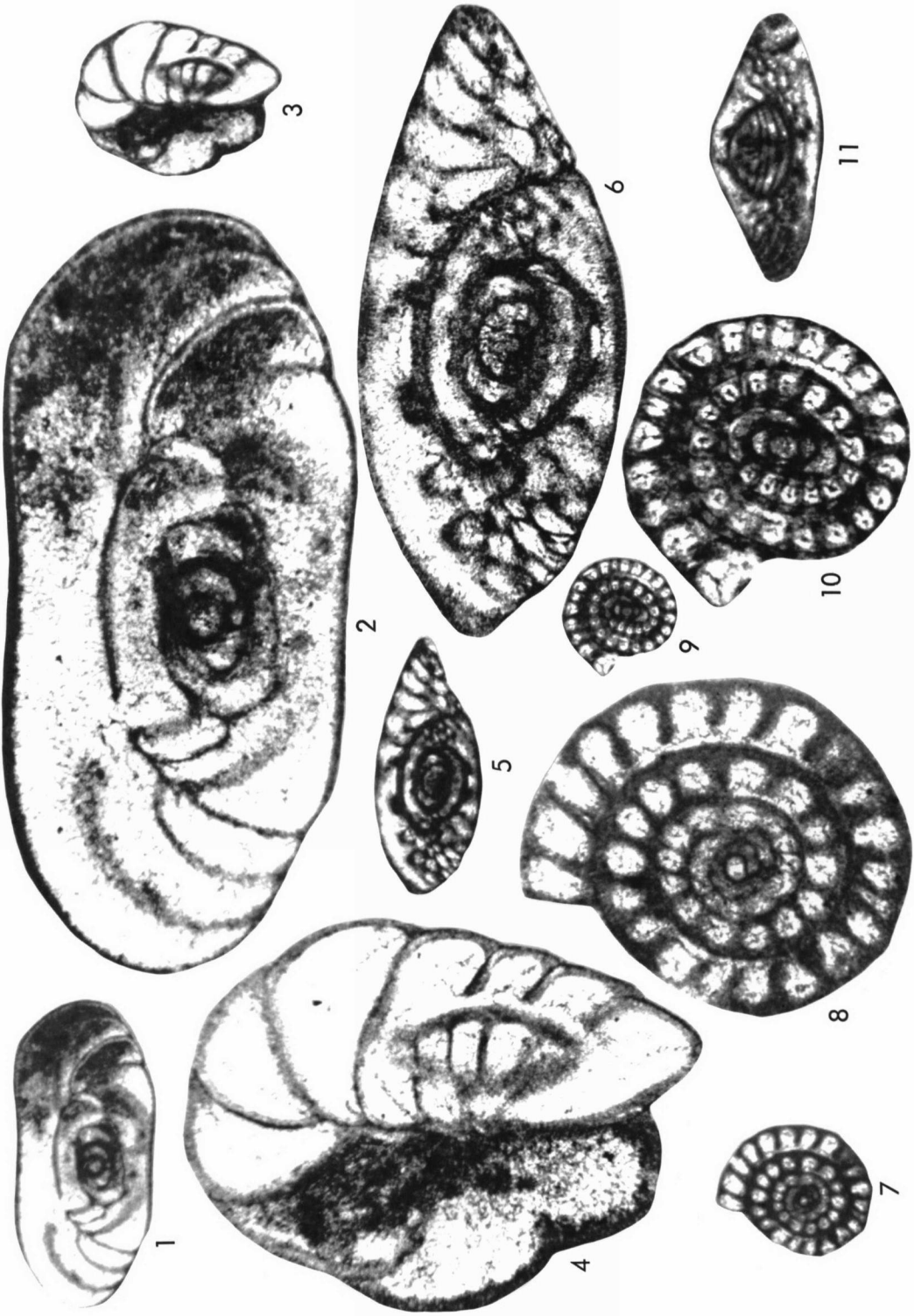
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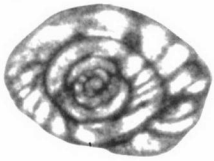

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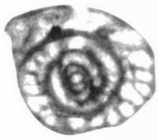

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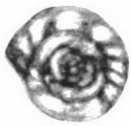

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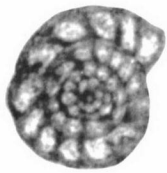

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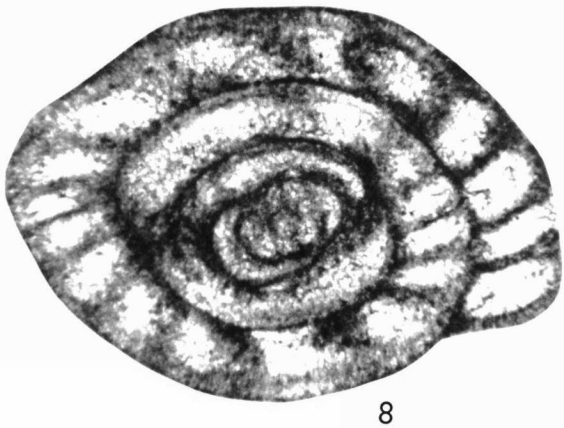

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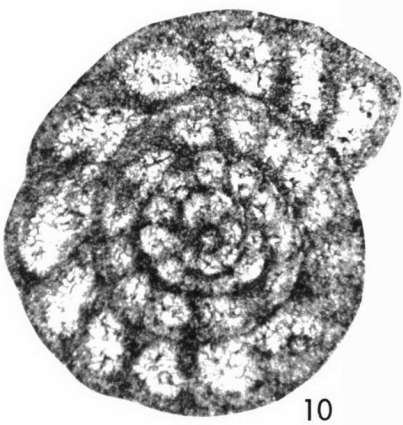

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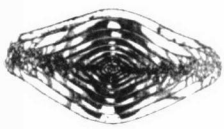

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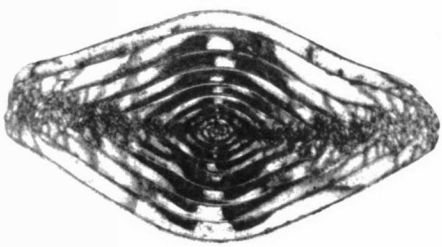

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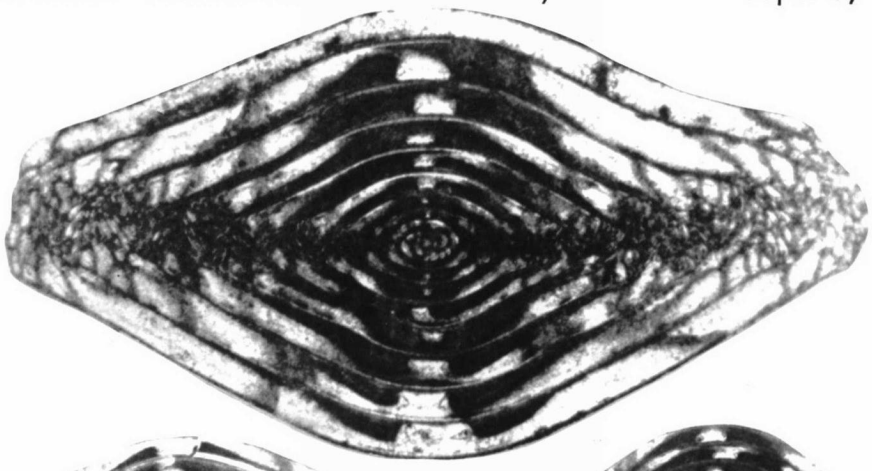

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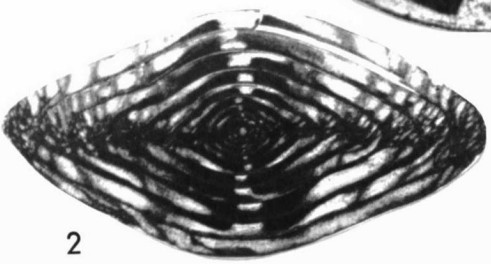

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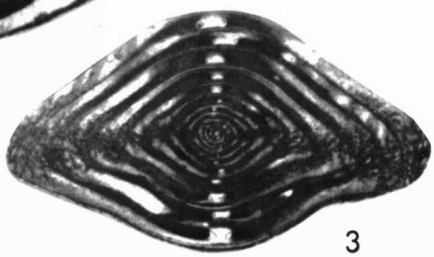

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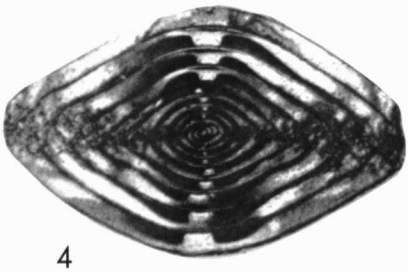

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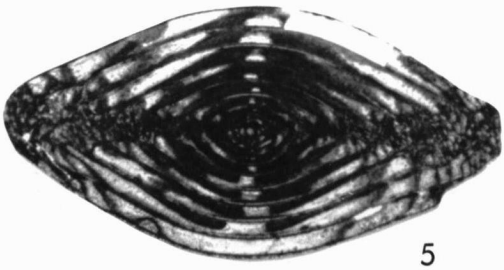

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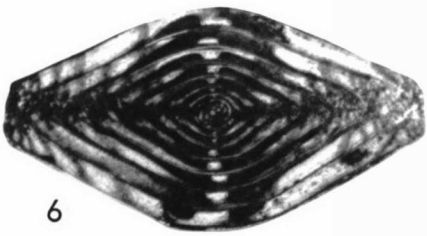

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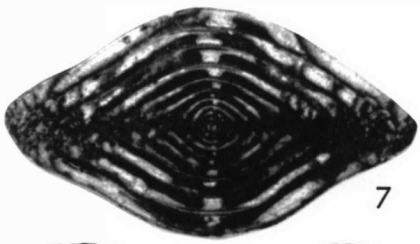

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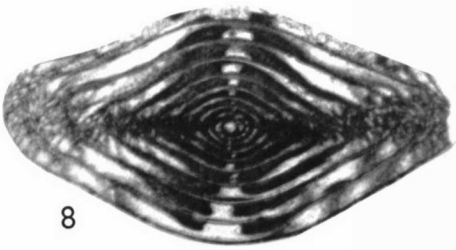

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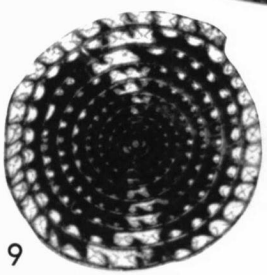

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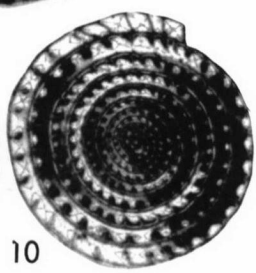

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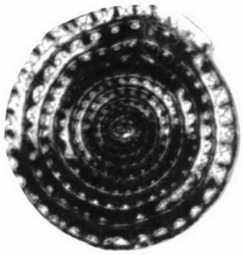

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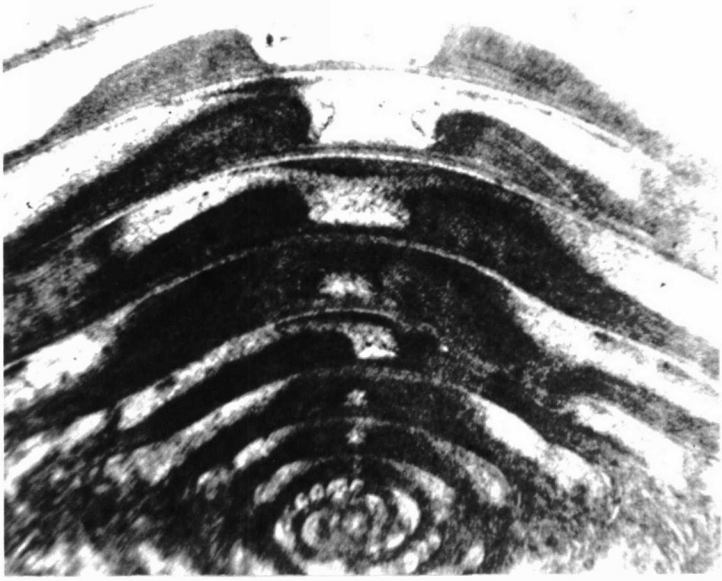

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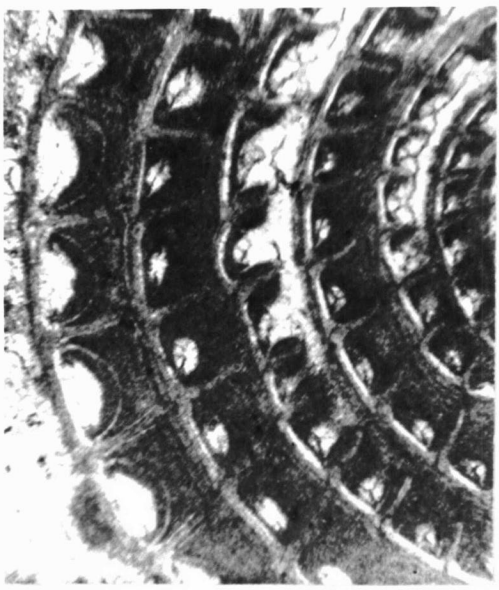

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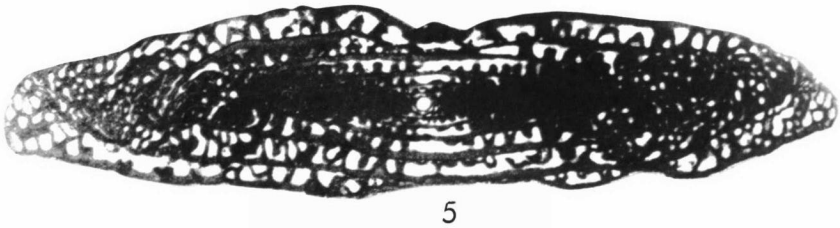

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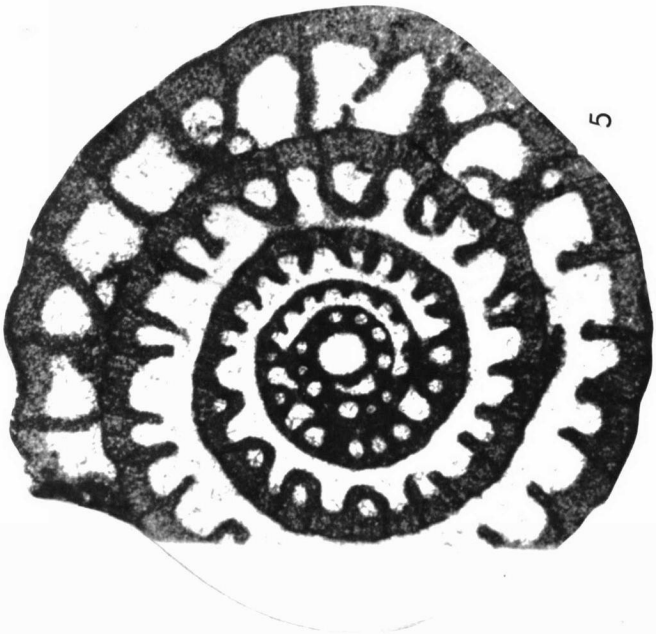

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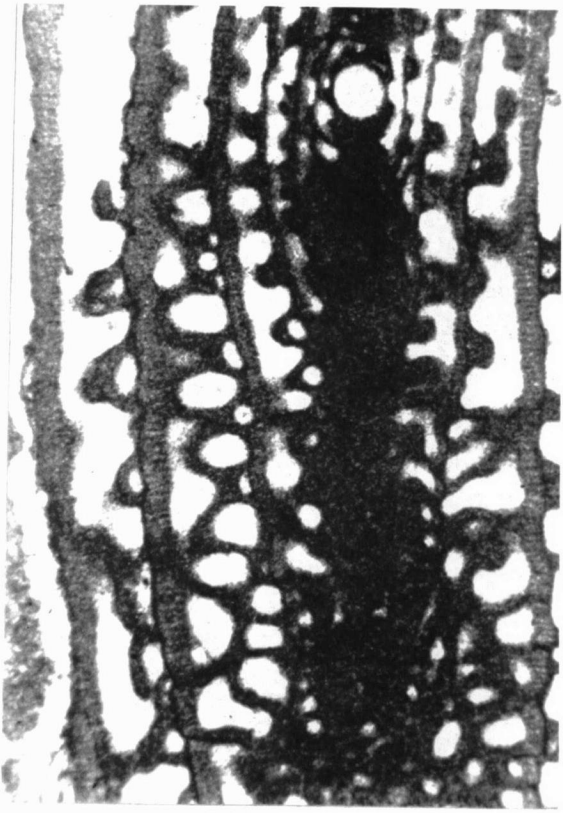

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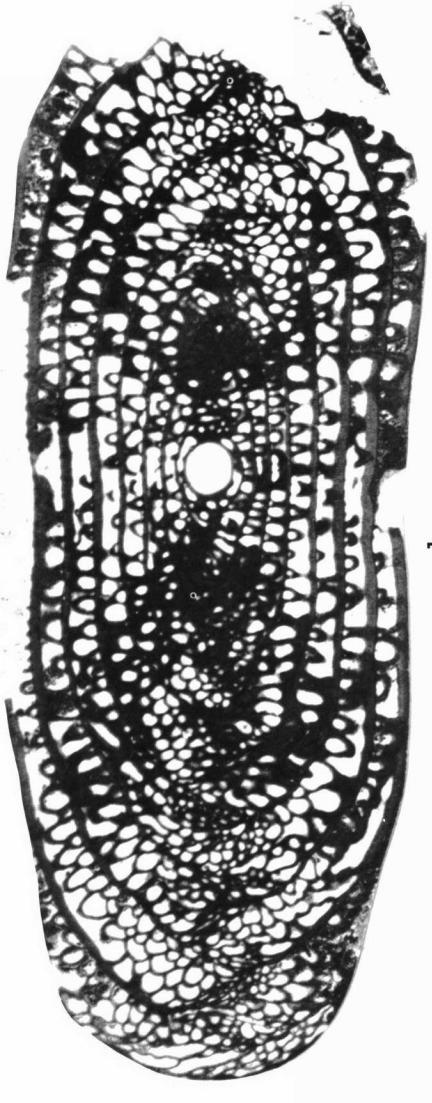

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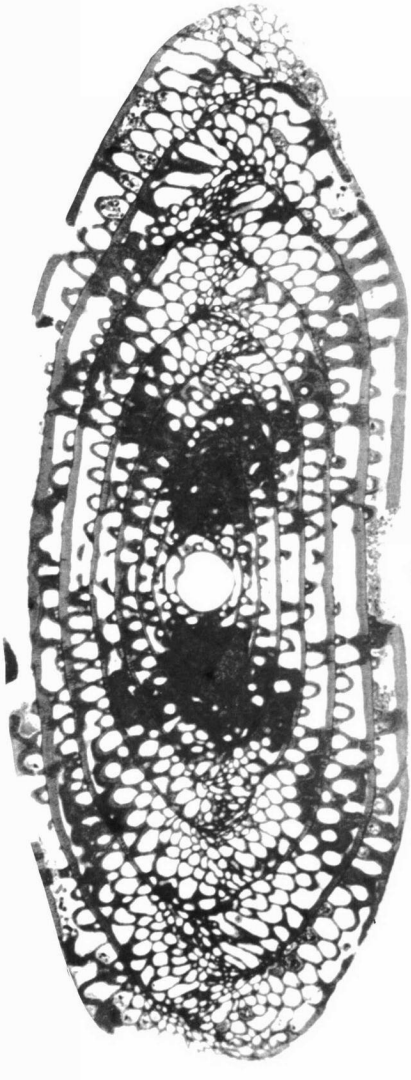

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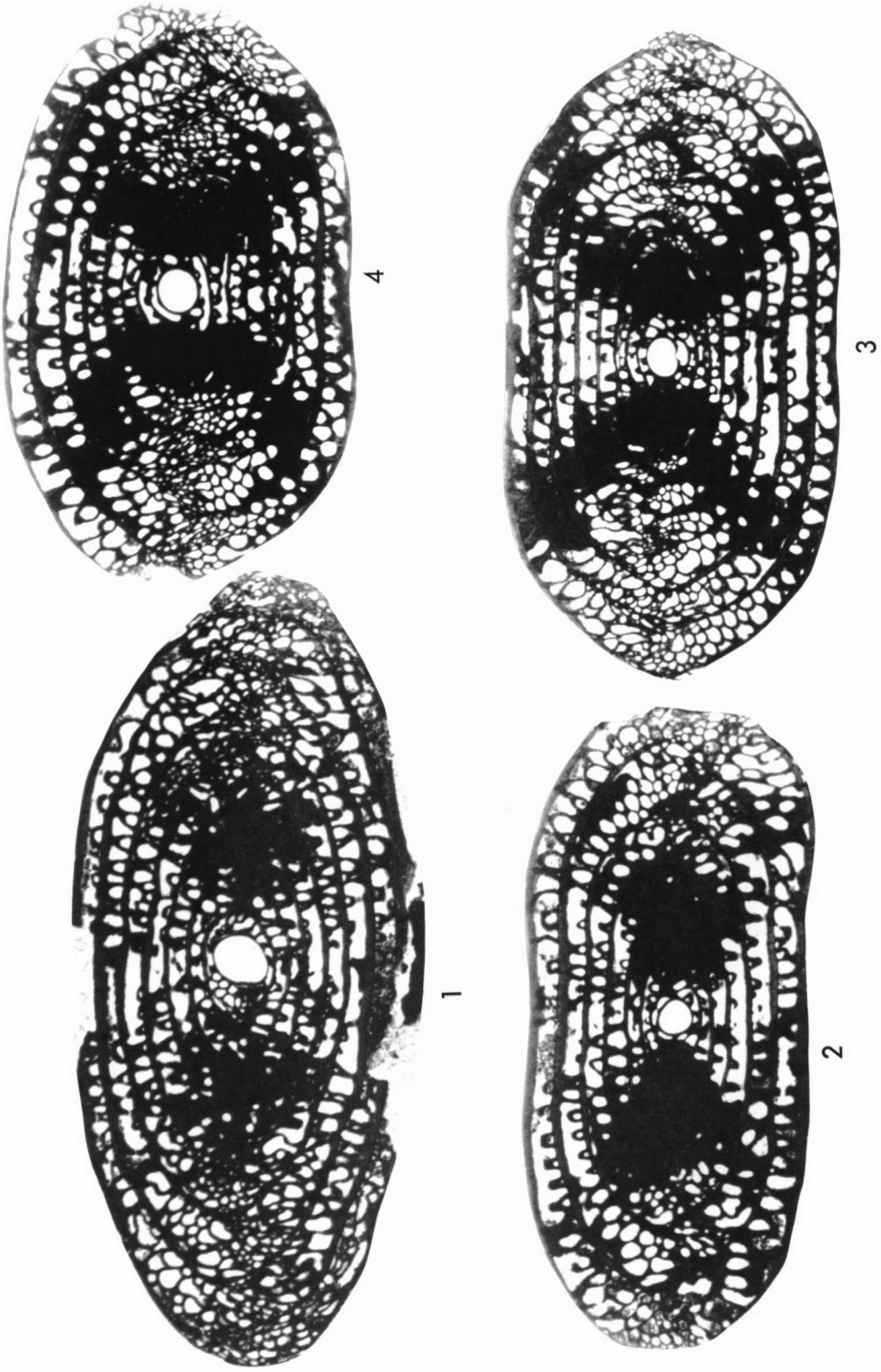
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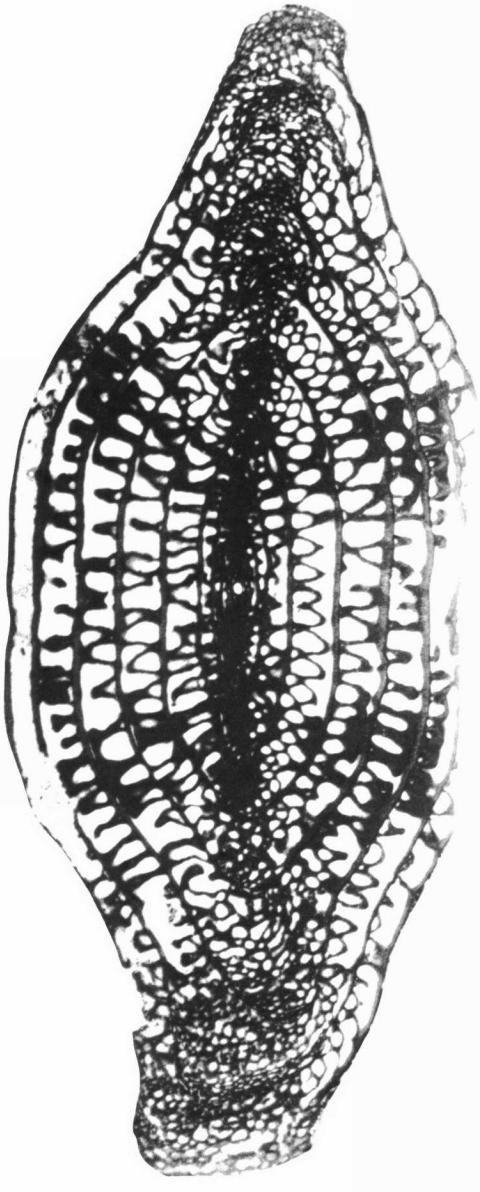

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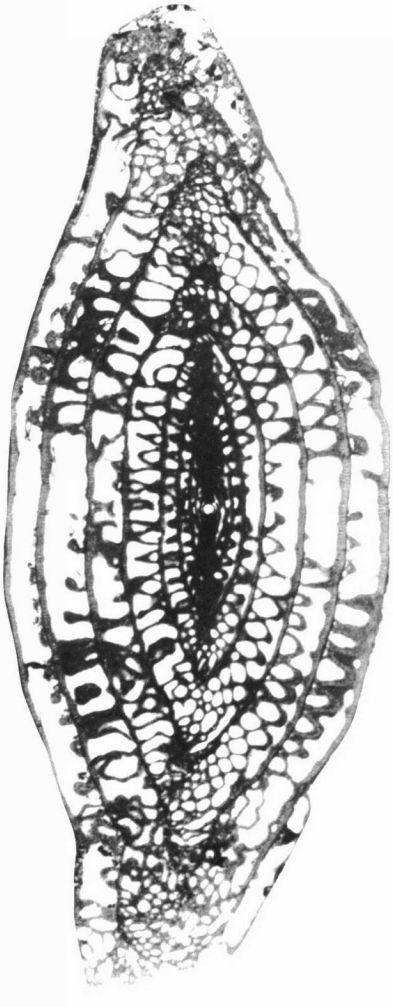

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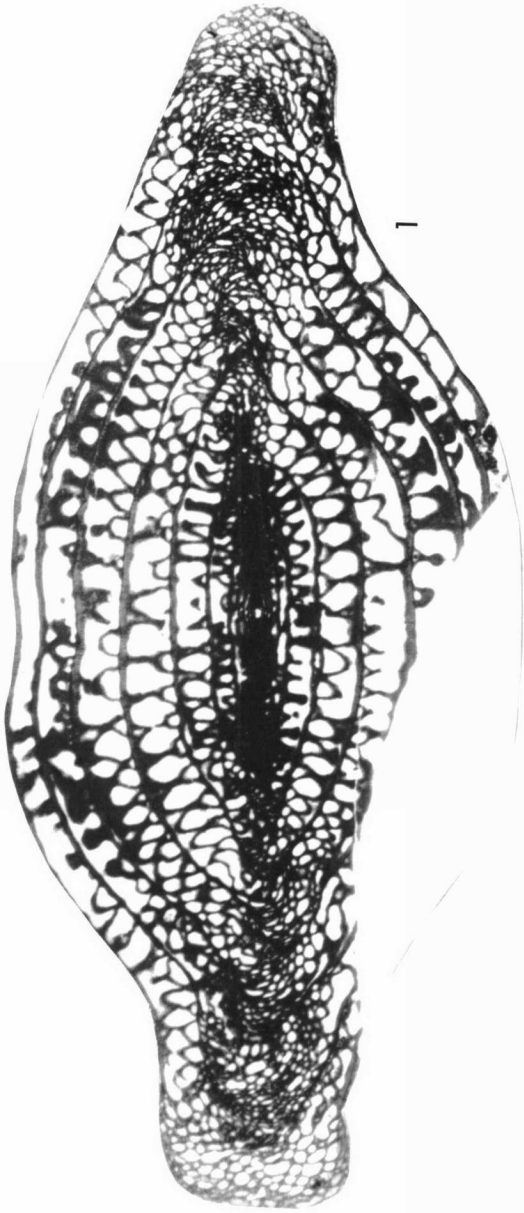

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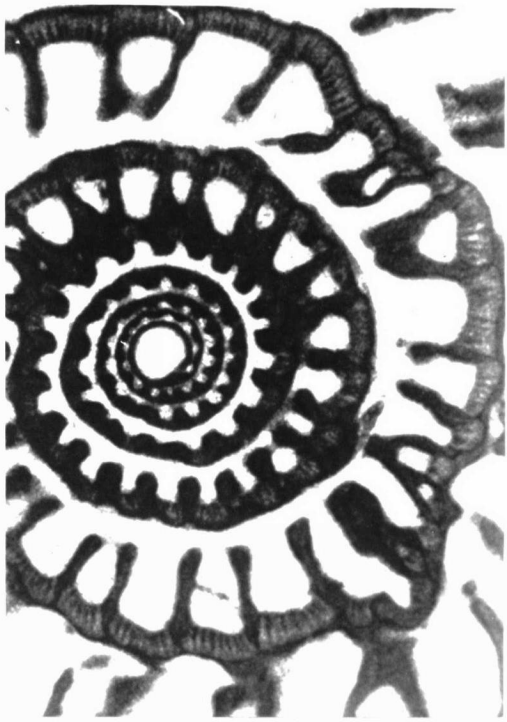

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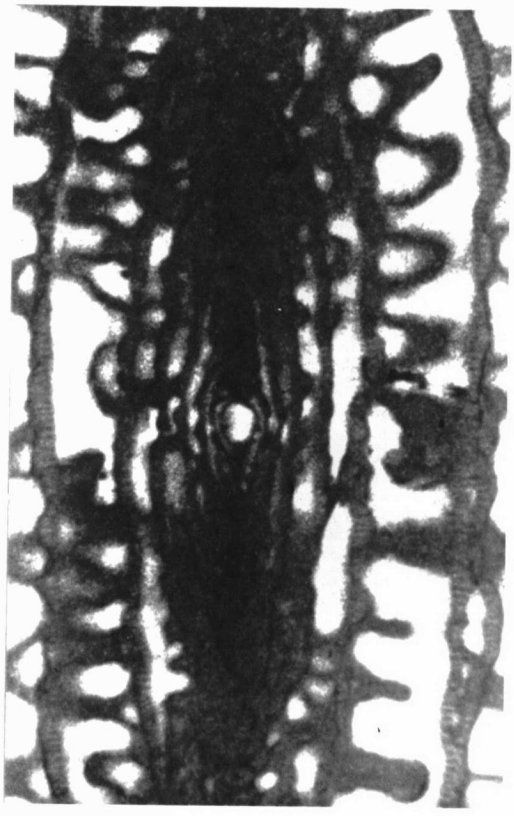

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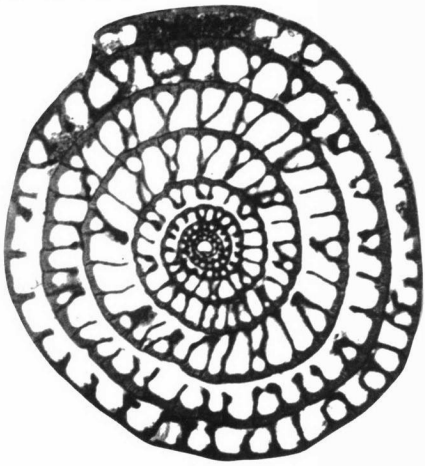

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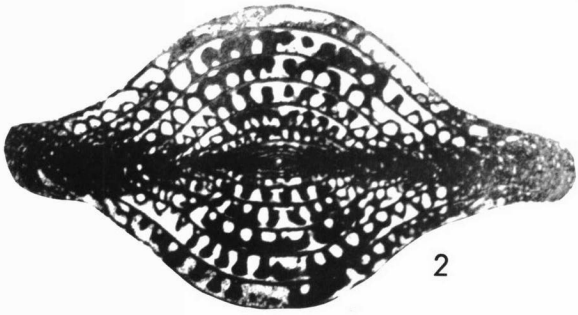

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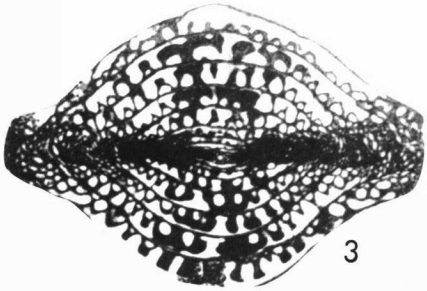

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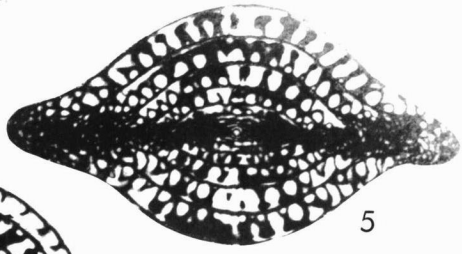

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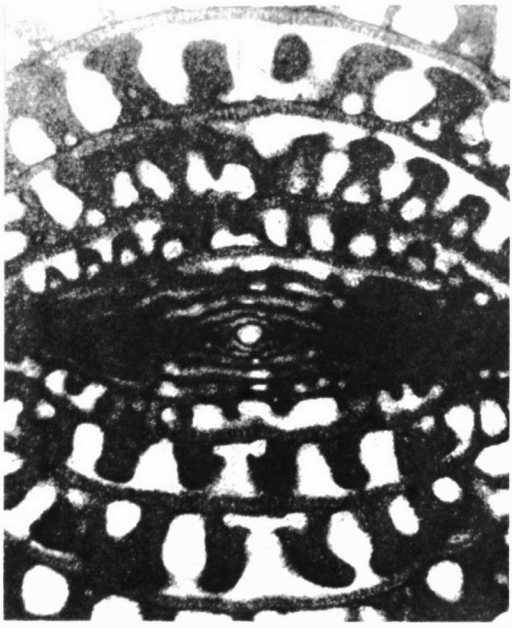

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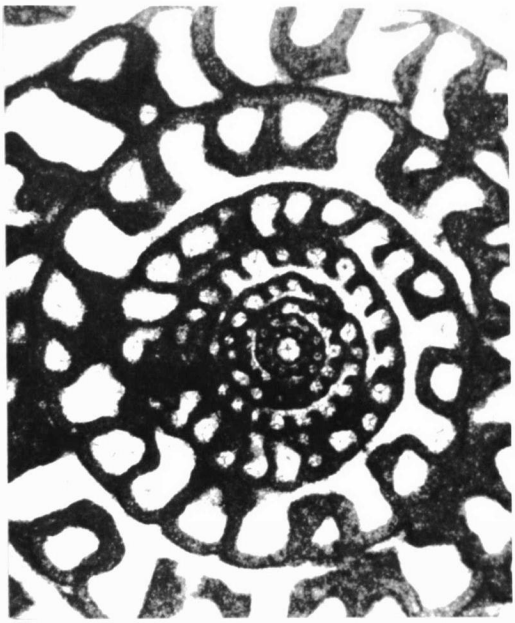

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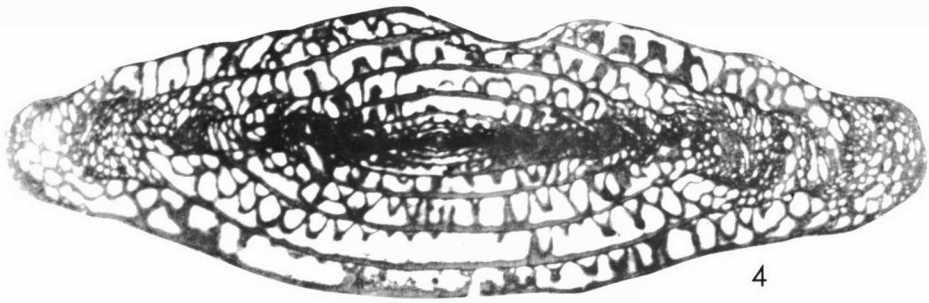

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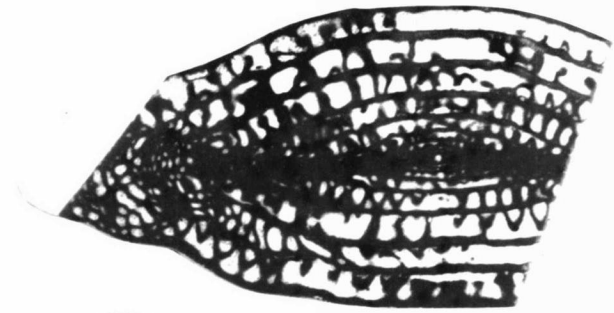

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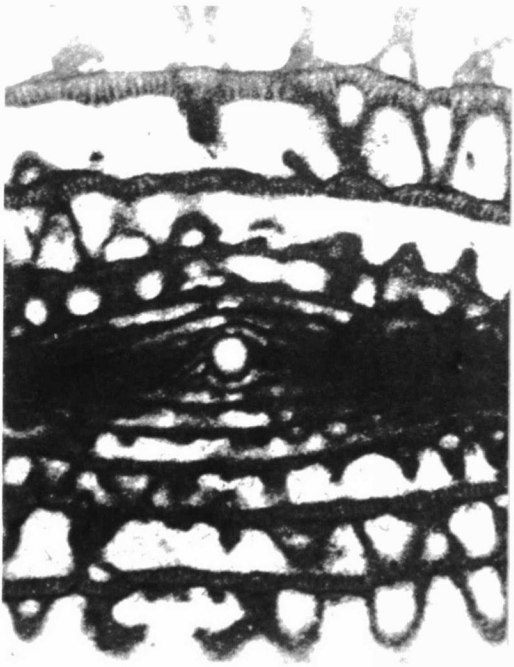

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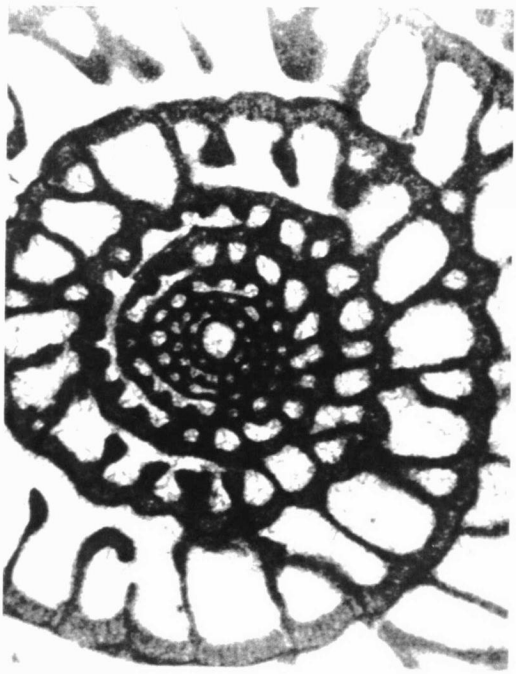

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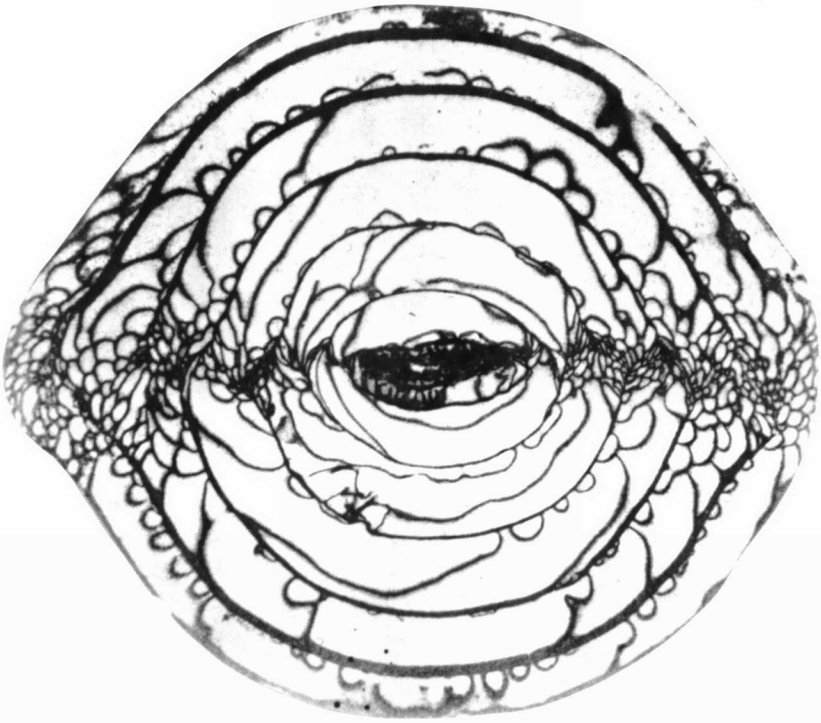

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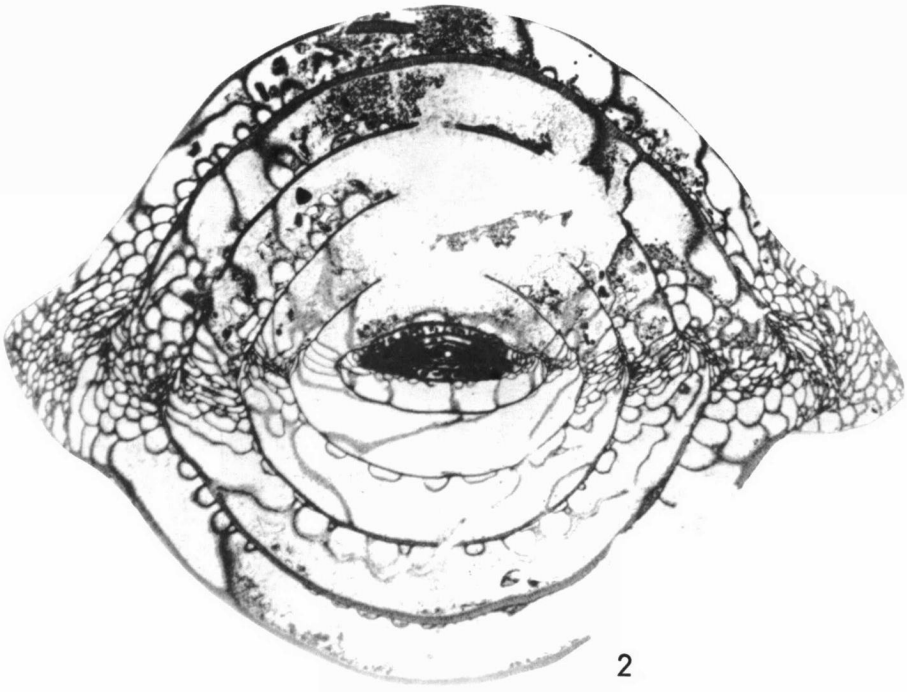

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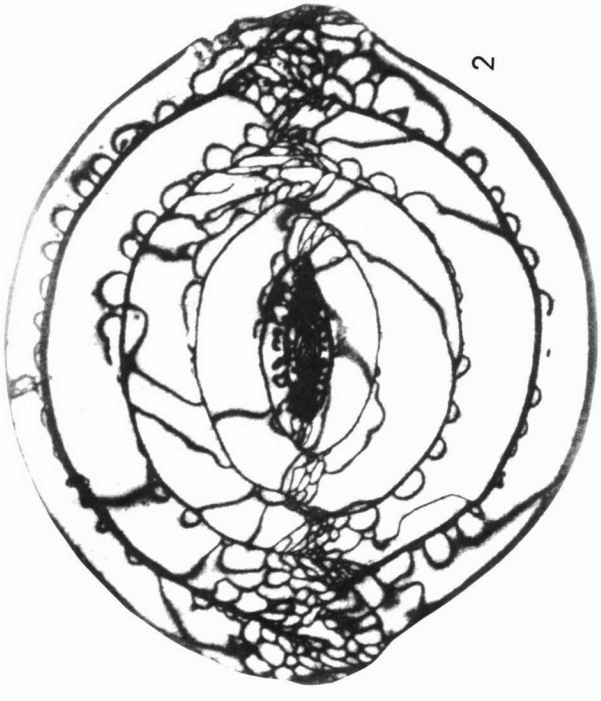

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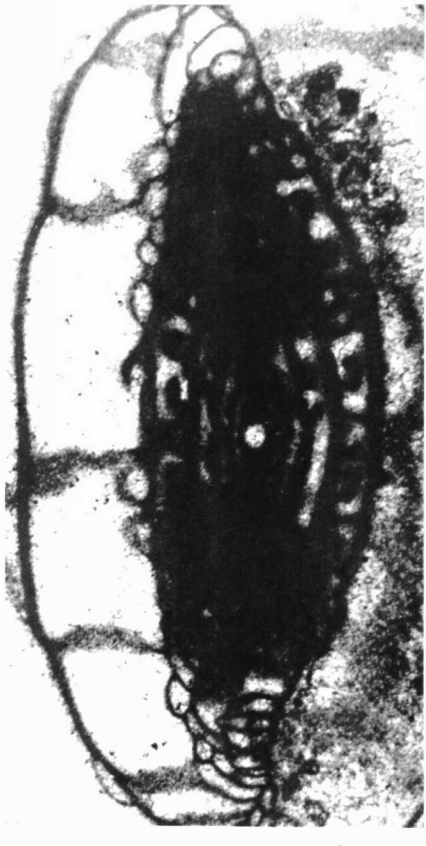

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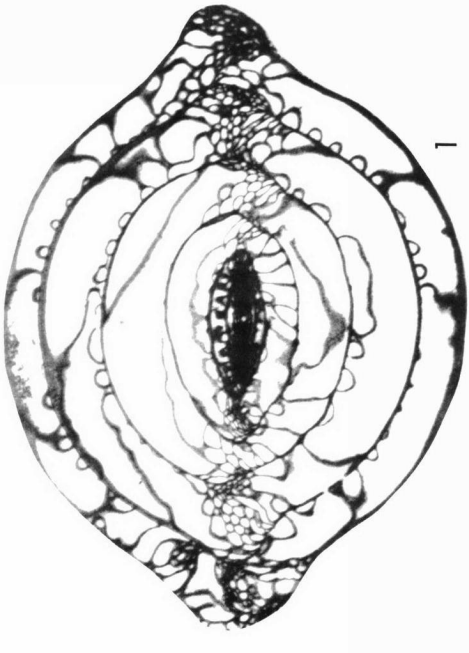

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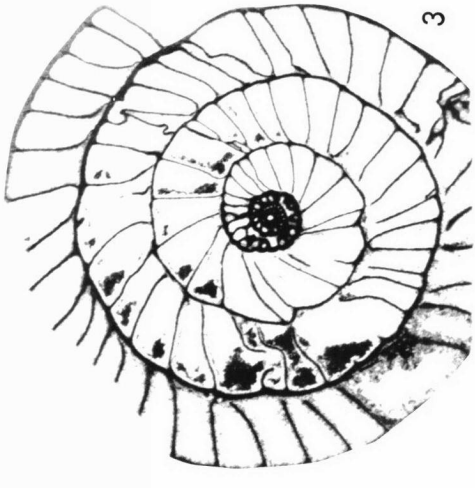

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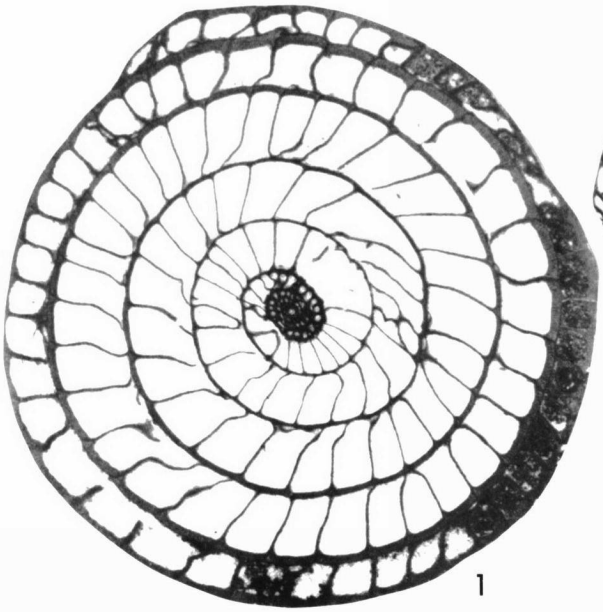

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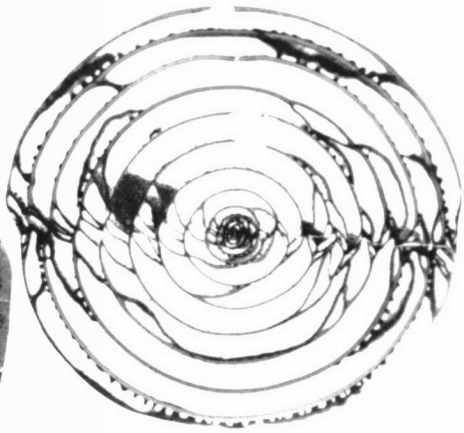

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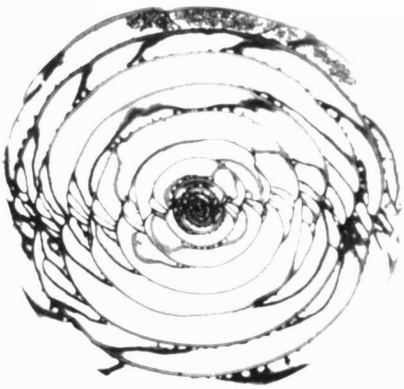

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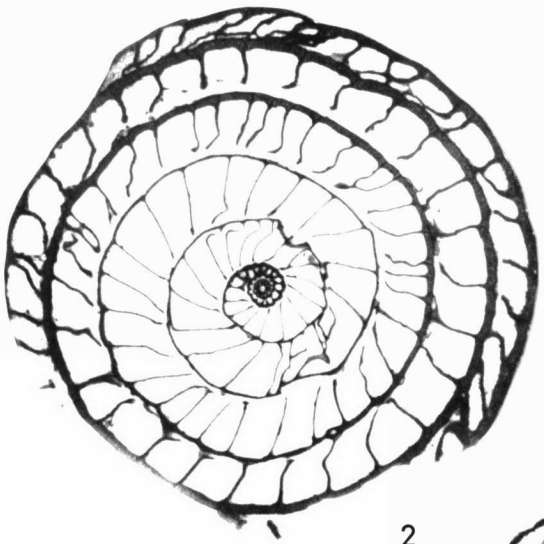

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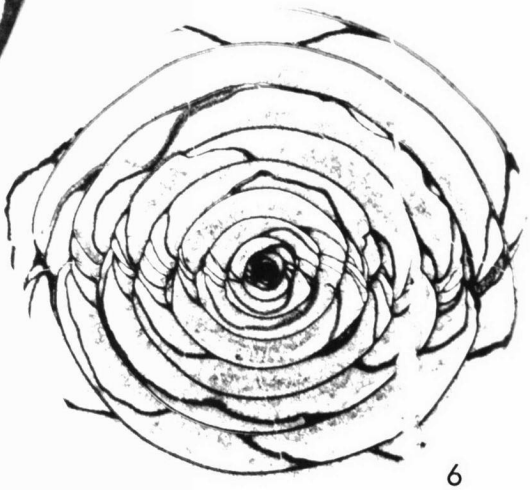

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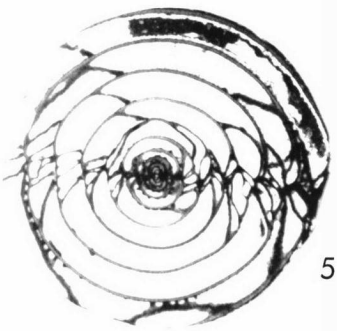

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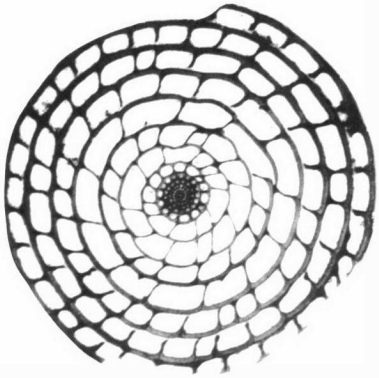

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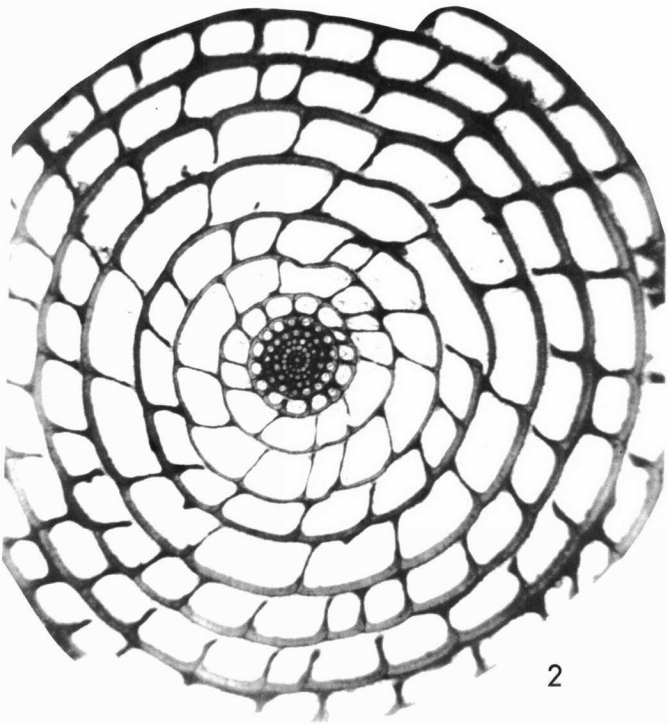

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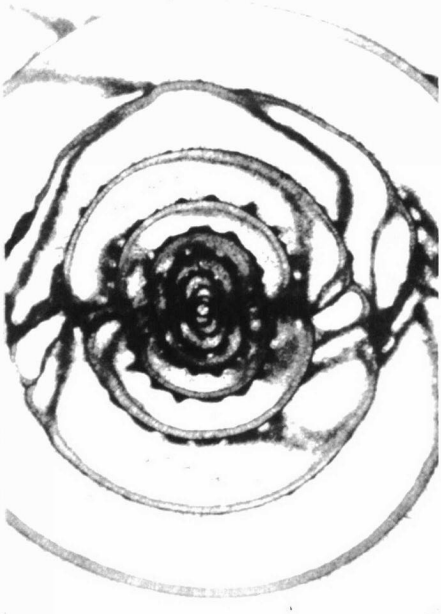

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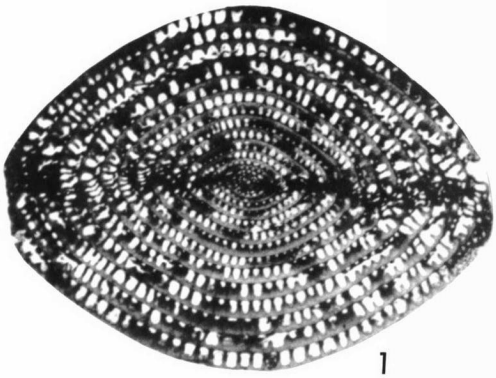

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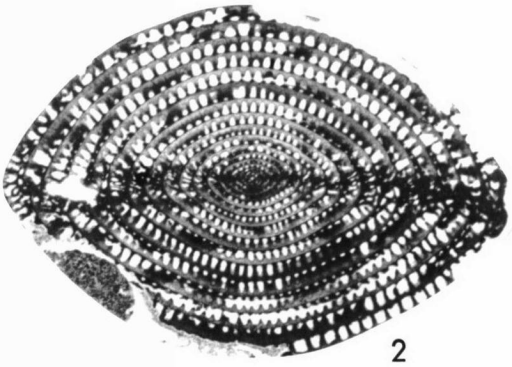

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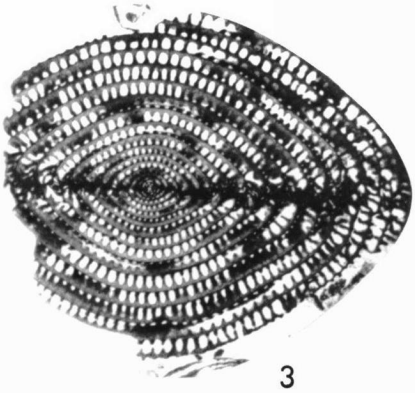

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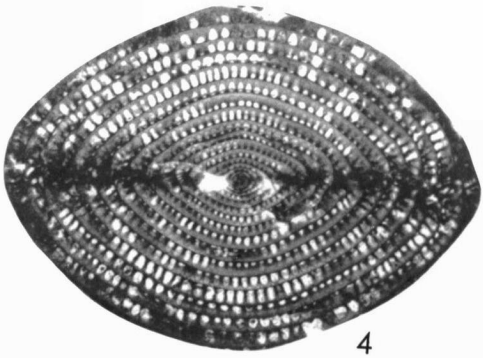

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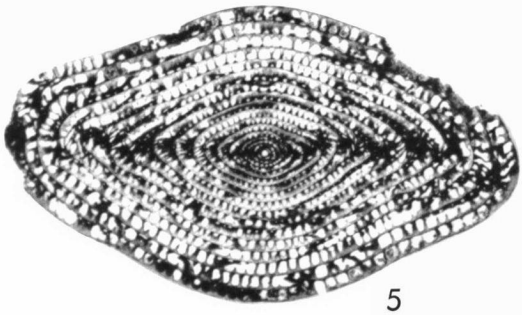

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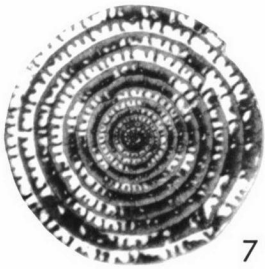

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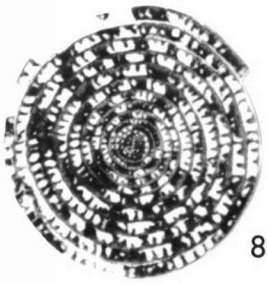

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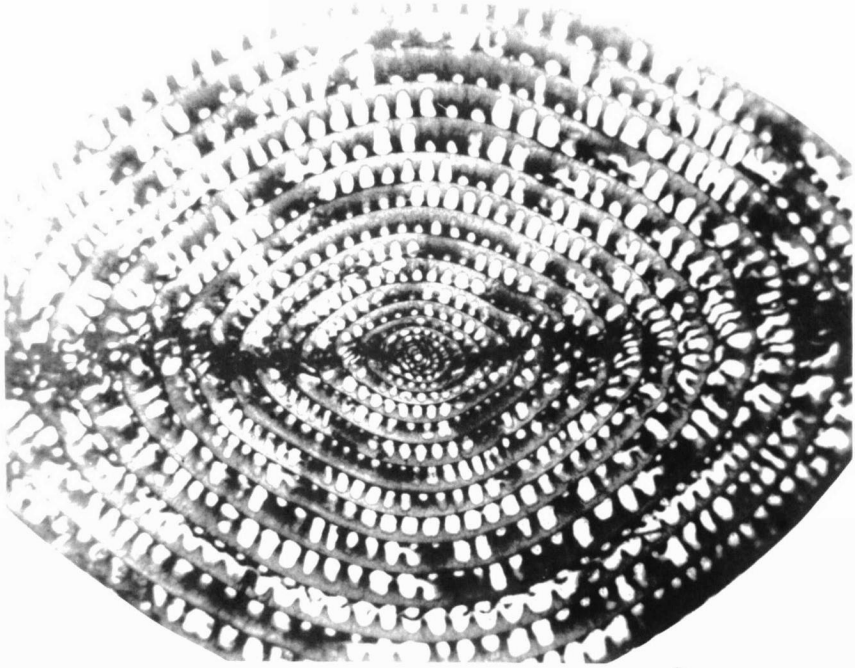

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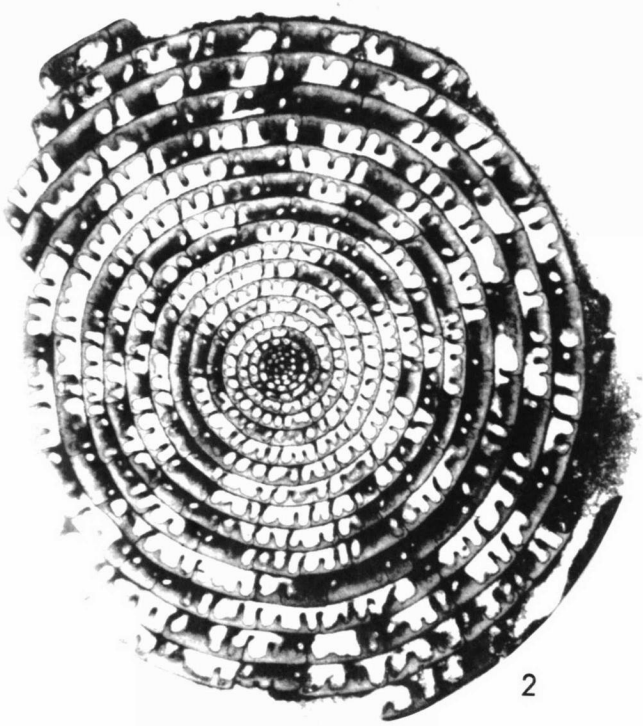

2

section they number 9 in 1st whorl, 15 in 2nd, 22 in 3rd, and 26 in 4th.

Proloculus ellipsoidal, rather than spherical. In three specimens it measures 133 by 236 μ, 197 by 219 μ, and 179 by 197 μ, respectively. Tunnel moderately wide and about one-half as high as chambers. In 5th whorl tunnel angle measures 42 to 56 degrees. Weak chomata present in first 1 or 2 volutions, but absent thereafter.

Discussion.—Pseudofusulina anachrona is a rare species, for we have found only a few specimens in our material. It does not closely resemble any previously described member of the genus, although there are superficial similarities to several species of *Schwagerina*, such as *S. longissimoidea* (Beede). It differs from this group in the "rugosity" of its spirotheca. It is the youngest member of the genus presently known, most species being restricted to beds of Wolfcampian age.

Occurrence.—We have found only a few specimens of this species in collection S-5, where it is associated with *Chusenella (Sosioella) sosioensis* Pasini, *C. (S.) glenisteri* Skinner & Wilde, n. sp., *C. (S.) intermedia* Skinner & Wilde, n. sp., *Rugososchwagerina yabei* (von Staff), and *Yangchienia thompsoni* Skinner & Wilde, n. sp.

Illustrations.——Plate 6, figure *5*; Plate 7, figures *1-5*.——Pl. 6, fig. *5*. Axial section of holotype, ×10.——Pl. 7, figs. *1-2*. Axial sections of paratypes, ×10.——Pl. 7, fig. *3*. Sagittal section of paratype, ×10.——Pl. 7, fig. *4*. Part of specimen shown in *1*, ×40, showing "rugosity" of spirotheca.——Pl. 7, fig. *5*. Specimen shown in 3, ×40. [All from collection S-5.] [All figures are unretouched photographs.]

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA DAINELLII Skinner & Wilde, n. sp.

Fusulina cylindrica Silvestri, 1933, Mem. dell'Inst. Geol. della R. Univ. di Padova, v. 10, p. 24-26, pl. 2, figs. 1-3.

Fusulina montipara Silvestri *(partim)*, 1933, same, p. 21-23, pl. 1, fig. 9 (*not* pl. 2, figs. 5, 6).

Shell large, thickly cylindrical, with bluntly rounded poles. This species is highly variable in proportions of length to diameter, but an almost complete gradational series between extremes leaves little doubt that all specimens belong to a single species. Mature specimens have 6.5 to 8.5 volutions, and measure 8.65 to 16.20 mm. in length and 4.10 to 5.50 mm. in diameter. Form ratio varies from 1.69 to 2.94.

Spirotheca composed of tectum and coarsely alveolar keriotheca. In 7th volution its thickness ranges from 130 to 160 μ. Septa strongly and regularly fluted from pole to pole. They number 10 to 11 in 1st whorl, 18 to 22 in 2nd, 24 to 25 in 3rd, 29 to 32 in 4th, 33 to 38 in 5th, 41 in 6th, and 41 in 7th. Septal folds high, usually reaching tops of chambers. Septal pores numerous, usually appearing as dark spots on septa because of having been plugged with secondary material. Axial filling commonly massive (Pl. 9, figs. *2-4*), but this character is variable and deposits may be only slightly developed (Pl. 8, fig. *1*). Filling most commonly produces an X-shaped pattern when observed in axial sections, with limbs of the X intersecting at the proloculus (Pl. 8, fig. *2*, Pl. 9, figs. *3-4*). [Sporadic cuniculi may be present immediately adjacent to tunnel in outer whorls, and it might be argued that this should place the species in the genus *Parafusulina*. It is our belief,

EXPLANATION OF PLATES

Plate 11, figures 1-3, *Chusenella (Sosioella) sosioensis* Skinner & Wilde, n. sp. (p. 11).

Plate 12, figure 1, *Chusenella (Sosioella) sosioensis* (p. 11); figures 2-10, *C. (S.) glenisteri* Skinner & Wilde, n. sp. (p. 12).

Plate 13, figures 1-2, *Chusenella (Sosioella) glenisteri* (p. 12); figures 3-5, *C. (S.) intermedia* Skinner & Wilde, n. sp. (p. 12).

Plate 14, figures 1-7, *Chusenella (Sosioella) intermedia* (p. 12).

Plate 15, figures 1-2, *Rugososchwagerina yabei* (von Staff) (p. 13).

Plate 16, figures 1-4, *Rugososchwagerina yabei* (p. 13).

Plate 17, figures 1-2, *Rugososchwagerina yabei* (p. 13); figures 3-5, *Verbeekina furnishi* Skinner & Wilde, n. sp. (p. 14); figure 6, *V. verbeeki* (Geninitz) (p. 14).

Plate 18, figures 1-4, *Verbeekina furnishi* (p. 14).

Plate 19, figures 1-8, *Neoschwagerina sosioensis* Skinner & Wilde, n. sp. (p. 15).

Plate 20, figures 1-2, *Neoschwagerina sosioensis* (p. 15).

[For explanation of Plates 1-10, see page 8.]

however, that it should be classified as a highly advanced species of *Schwagerina* since the cuniculi are poorly developed and not consistently present.]

Proloculus very large and commonly slightly distorted in shape. Its outside diameter varies from 483 to 832 μ, averaging about 650 μ. Tunnel rather narrow and about one-half as high as chambers. In 7th volution tunnel angle measures 20 to 35 degrees, averaging about 28 degrees. Chomata are absent.

Discussion.—Silvestri (1933) described this species as *Fusulina cylindrica* Fischer. His illustrations consisted of two external views and one axial section. In addition, he figured as *Fusulina montipara* (Ehrenberg) an external view of a specimen which is probably closely similar to our shorter examples of *Schwagerina dainellii* (Pl. 9, figs. *3-4*), which does not closely resemble any previously described species. As pointed out above, it is extremely variable in length, although the diameter is fairly constant. This produces marked variations in form ratio. We have illustrated six axial sections which show the gradation from one extreme to the other. This species is named for Dr. Leonardo Dainelli who collected our material.

Occurrence.—We have found this species in collections S-3 and S-7, from the Pietra di Salomone, where it is associated with *Neoschwagerina sosioensis* Skinner & Wilde, n. sp., and *Verbeekina furnishi* Skinner & Wilde, n. sp. Silvestri's specimens came from the same locality.

Illustrations.—Plate 8, figures *1-4*; Plate 9, figures *1-4*.——Pl. 8, fig. *1*. Axial section of holotype, ×10.——Pl. 8, fig. *2*. Axial section of paratype, ×10.——Pl. 8, figs. *3-4*. Sagittal sections of paratypes, ×10.——Pl. 9, figs. *1-4*. Axial sections of paratypes, ×10, showing marked variation in proportions within this species. [All from collection S-3.] [All figures are unretouched photographs.]

Genus CHUSENELLA Hsu, 1942

[emend. Chen, 1955]

Subgenus SOSIOELLA Skinner & Wilde, n. subgen.

Type species: *Chusenella sosioensis* Pasini, 1964.

Diagnosis.—Shell small to large, with inflated central portion and extended, conical, bluntly to sharply pointed ends. Mature individuals of type species usually have 9 to 11 whorls, first 4 to 6 of which constitute tightly coiled, slender, elongated juvenarium, with sharply pointed poles. Bilaterally symmetrical at all stages of growth. Spirotheca composed of tectum and rather coarsely alveolar keriotheca. It is "rugose" in juvenarium, but loses this character in more loosely coiled adult whorls. In fully grown specimens final 0.5 to 1 volution is reduced in height, constituting a gerontic stage. Phrenothecae slightly developed in some specimens, but never conspicuous. Septa intensely but somewhat irregularly folded from pole to pole, and septal folds extend to tops of chambers. Cuniculi not observed. Axial filling, in form of secondary deposit on septa, well developed in juvenarium and present in band on either side of equatorial zone in later volutions. Tunnel 0.3 to 0.5 as high as chambers and usually narrow. In juvenarium it is bordered by weak chomata which are absent in adult stage.

Discussion.—Superficially, this subgenus resembles *Chusenella s.s.* and *Rugosochusenella.* It differs from the former in the septal fluting and "rugose" spirotheca of the juvenarium, and from the latter in the septal fluting in the juvenarium and loss of the spirothecal "rugosity" in the adult stage. It is distinguished from *Schwagerina* by the "rugose" spirotheca of the juvenarium, and from *Pseudofusulina* by the loss of spirothecal "rugosity" in the adult stage. At present only the three species described here are certainly known to belong to *Sosioella*, but it appears that *Dunbarinella alpina* Kochansky-Devidé & Ramovš, also, is a member of the subgenus. In addition, *Chusenella leei* Skinner & Wilde, *C. referta* Skinner & Wilde, and *C. cheni* Skinner & Wilde, from the Twin Lakes area of northwestern Washington, may belong here.

Age.—Middle Permian.

CHUSENELIA (SOSIOELLA) SOSIOENSIS Pasini, 1964

Fusulina prisca Silvestri, 1933, Mem. dell'Inst. Geol. della R. Univ. di Padova, v. 10, p. 19-21, pl. 1, figs. 6-7; pl. 2, fig. 4.

Fusulina montipara Silvestri *(partim)*, 1933, same, p. 21-23, pl. 2, figs. 5-6 (*not* pl. 1, fig. 9).

Chusenella sosioensis Pasini, 1964, Riv. Ital. Pal. Stratig., v. 70, no. 2, p. 172-178, pl. 10, figs. 1-4, pl. 11, figs. 1-4, text figs. 1-4.

Shell large, middle part thickly cylindrical, with extended, conical, bluntly pointed ends. Mature specimens have 9 to 11 volutions, first 4 to 6

of which constitute tightly coiled, slender, elongate juvenarium with sharply pointed poles. This is followed by more loosely coiled adult stage. In fully grown individuals final 0.5 to 1 volution constitutes a gerontic stage in which height of chambers is somewhat reduced. Such specimens measure 13.70 to 15.90 mm. in length and 5.10 to 6.50 mm. in diameter. Form ratio varies from 2.44 to 2.69.

Spirotheca composed of tectum and rather coarsely alveolar keriotheca. In juvenarium it is "rugose" (Pl. 11, fig. 2), but this character is absent in adult stage. Spirotheca thin in juvenarium, but in 9th volution it attains thickness of 92 to 130 μ. Septa intensely but somewhat irregularly fluted throughout shell. They number 9 to 12 in 1st volution, 14 to 15 in 2nd, 15 to 17 in 3rd, 20 in 4th, 23 to 24 in 5th, 28 to 30 in 6th, 35 in 7th, 39 to 41 in 8th, and 39 to 47 in 9th. Septal folds high, extending to tops of chambers. Very inconspicuous phrenothecae present in some specimens. Cuniculi absent. Axial filling in form of secondary deposits on septa well developed in juvenarium. In adult stage it produces thickening of septa in rather narrow zone about 0.3 of distance from tunnel to poles (Pl. 10, fig. *1*).

Proloculus rather small and usually ellipsoidal in shape. Its outside diameter varies from 125 to 210 μ, averaging about 160 μ. Tunnel narrow and about 0.3 to 0.5 as high as chambers. In 9th volution tunnel angle measures 20 to 22 degrees. Weak chomata present in juvenarium but not developed in adult stage.

Discussion.—Silvestri (1933) described and illustrated this species but misidentified it as *Fusulina prisca* (Ehrenberg). His illustrations consisted of two external views and one tangential section. In addition, he figured a tangential section and a parallel section as *Fusulina montipara* (Ehrenberg) which also belong to this species. None of his specimens resembles either of Ehrenberg's species, the first of which probably belongs in the genus *Pseudofusulina* and the second in *Schwagerina*. Pasini (1964) redescribed this species, assigning it to the genus *Chusenella* Hsu and naming it *C. sosioensis*. As pointed out in the subgeneric diagnosis of *Sosioella*, however, this species displays certain characters which remove it from *Chusenella s.s.* We do not know of any described species with which *Chusenella (Sosioella) sosioensis* is at all likely to be confused.

Occurrence.—We have found this species in collection S-2, from the Rocca di San Benedetto, where it is associated with *Kahlerina siciliana* Skinner & Wilde, n. sp., and *Rauserella staffi* Skinner & Wilde, n. sp., and in collection S-5, from the Pietra di Salomone, where it is associated with *Rugososchwagerina yabei* (von Staff), *Chusenella (Sosioella) glenisteri* Skinner & Wilde, n. sp., *C. (S.) intermedia* Skinner & Wilde, n. sp., *Yangchienia thompsoni* Skinner & Wilde, n. sp., and *Pseudofusulina anachrona* Skinner & Wilde, n. sp. Silvestri, however, cited it as occurring in all four of the Sosio Limestone blocks. Pasini's redescription was based on specimens from Silvestri's collections. The holotype and six of the seven figured paratypes came from the Pietra di Salomone, while the other paratype was collected from the Rocca di San Benedetto. This last specimen, incidentally, is the one figured by Silvestri as figure 4 of his plate 2.

Illustrations.—Plate 10, figures *1-3*; Plate 11, figures *1-3*; Plate 12, figure *1*.——Pl. 10, fig. *1-2*. Axial sections of topotypes, ×10.——Pl. 10, fig. *3* Sagittal section of topotype, ×10. [All from collection S-2.]——Pl. 11, figs. *1-2*. Axial section of topotype, ×10, and part of same specimen, ×40, showing "rugosity" of spirotheca in juvenarium.——Pl. 11, fig. *3*. Part of specimen shown in Pl. 10, fig. *3*, ×40. [Both from collection S-2.] ——Pl. 12, fig. *1*. Sagittal section of topotype, ×10. [From collection S-5.] [All figures are unretouched photographs.]

CHUSENELLA (SOSIOELLA) GLENISTERI Skinner & Wilde, n. sp.

Shell small, central portion subglobular, with sharply extended, pointed poles. Mature individuals have 9.5 to 11 whorls, first 4 to 5 of which constitute tightly coiled, slender, elongate juvenarium with sharply pointed poles. This is followed by loosely coiled adult stage whose whorls are progressively more inflated. In fully grown specimens the final 0.5 to 1 volution is reduced in height, indicating gerontic stage. Such individuals measure 5.64 to 7.49 mm. in length and 3.73 to 3.96 mm. in diameter. Form ratio varies from 1.51 to 1.89.

Spirotheca, composed of tectum and rather coarsely alveolar keriotheca, is very thin in tightly coiled juvenarium where structure of keriotheca is commonly obscure. In 8th whorl it attains

thickness of 40 to 53 μ. In juvenarium, and rarely in following 1 or 2 whorls, spirotheca is "rugose." Septa moderately fluted in juvenarium and intensely fluted throughout adult stage. They number 7 to 11 in 1st whorl, 11 to 12 in 2nd, 13 to 15 in 3rd, 15 to 19 in 4th, 17 to 21 in 5th, 18 to 25 in 6th, 23 to 27 in 7th, 25 to 34 in 8th, 30 to 35 in 9th, and 36 to 38 in 10th. Septal folds high, reaching nearly to tops of chambers, their height commonly greater than width. In addition, they are wider at base and top than in middle, commonly giving septal loops, as seen in axial section, an elongated, somewhat distorted hour-glass outline (Pl. 12, figs. *2-5*). Neither phrenothecae nor cuniculi have been observed. Axial filling, in form of thick secondary deposits on septa, present throughout shell. This commonly causes upper part of septal loops to appear as solid masses rather than open loops. In sagittal sections secondary deposits cause septa to appear thickly club-shaped, thicker at ends than at tops (Pl. 12, figs. *6, 9*).

Proloculus very small, its outside diameter ranging from 76 to 130 μ, averaging 102 μ. Tunnel narrow, low, and somewhat erratic in its course. In 9th volution tunnel angle measures 19 to 20 degrees. Very weak chomata present in juvenarium, but absent in later whorls.

Discussion.—In its shape and the character of its septal fluting *Chusenella (Sosioella) glenisteri* resembles *Chusenella douvillei* (Colani) and *C. globularis* (Gubler). It differs from both, however, in its smaller size and the "rugosity" of its spirotheca. This species is named for Dr. B. F. Glenister.

Occurrence.—This species is abundant in collection S-5, from the Pietra di Salomone, but we have not found it in any other of our collections. It is associated with *Yangchienia thompsoni* Skinner & Wilde, n. sp., *Rugososchwagerina yabei* (von Staff), *Chusenella (Sosioella) sosioensis* Pasini, *C. (S.) intermedia* Skinner & Wilde, n. sp., and *Pseudofusulina anachrona* Skinner & Wilde, n. sp.

Illustrations.—Plate 12, figures *2-10*; Plate 13, figures *1-2*.——Pl. 12, fig. *2*. Axial section of the holotype, ×10.——Pl. 12, figs. *3-5*. Axial sections of paratypes, ×10.——Pl. 12, figs. *6-10*. Sagittal sections of paratypes, ×10.——Pl. 13, fig. *1*. Part of holotype, ×40.——Pl. 13, fig. *2*. Part of specimen shown in Pl. 12, fig. *8*, ×40. [All from collection S-5.] [All figures are unretouched photographs.]

CHUSENELLA (SOSIOELLA) INTERMEDIA Skinner & Wilde, n. sp.

Shell large, elongate fusiform, with slightly convex lateral slopes and bluntly pointed poles. Mature specimens have 8 to 9.5 volutions, first 4 or 5 of which form tightly coiled, slender, elongate juvenarium with sharply pointed poles. This is followed by more loosely coiled adult stage. Such specimens measure 10.15 to 12.19 mm. in length and 3.64 to 3.91 mm. in diameter. Form ratio varies from 2.73 to 3.11.

Spirotheca composed of tectum and coarsely alveolar keriotheca. In 8th whorl its thickness measures 101 to 118 μ. In juvenarium spirotheca is "rugose," but this character is absent in adult stage. Septa strongly but irregularly fluted throughout shell. They number 8 to 9 in 1st volution, 12 to 15 in 2nd, 13 to 17 in 3rd, 15 to 18 in 4th, 18 to 22 in 5th, 21 to 28 in 6th, 24 to 30 in 7th, 26 to 33 in 8th, and 31 to 34 in 9th. Septal folds high, extending to tops of chambers. Neither phrenothecae nor cuniculi have been observed. Slight axial filling in form of secondary deposits on septa present throughout shell, but it is inconspicuous except in juvenarium.

Proloculus small, its outside diameter varying from 104 to 187 μ. Tunnel low and narrow. In 8th whorl tunnel angle measures 28 to 32 degrees. Very weak chomata present in juvenarium but absent in adult stage.

Discussion.—Chusenella (Sosioella) intermedia bears some resemblance to *C. (S.) sosioensis* Pasini, with which it occurs. It differs from that species, however, in its smaller size, more regularly fusiform shape, and lesser development of secondary deposits. We know of no other species with which it is likely to be confused.

Occurrence.—This is a relatively rare species, and we have found only a few specimens in collection S-5, from Pietra di Salomone. It is associated with *Yangchienia thompsoni* Skinner & Wilde, n. sp., *Rugososchwagerina yabei* (von Staff), *Chusenella (Sosioella) sosioensis* Pasini, *C. (S.) glenisteri* Skinner & Wilde, n. sp., and *Pseudofusulina anachrona* Skinner & Wilde, n. sp.

Illustrations.—Plate 13, figures *3-5*; Plate 14, figures *1-7*.——Pl. 13, fig. *3*. Axial section of holo-

type, ×10.——Pl. 13, figs. *4-5*. Axial sections of paratypes, ×10.——Pl. 14, fig. *1*. Axial section of paratype, ×10.——Pl. 14, figs. *2-5*. Sagittal sections of paratypes, ×10.——Pl. 14, fig. *6*. Part of holotype, ×40.——Pl. 14, fig. *7*. Part of specimen shown in fig. *4*, ×40. [All from collection S-5.] [All figures are unretouched photographs.]

Genus RUGOSOSCHWAGERINA Miklukho-Maklay, 1959

RUGOSOSCHWAGERINA YABEI (von Staff)

Schwagerina yabei von Staff, 1909, Neues Jahrb. Min., Geol., und Pal., v. 27, p. 463-468, pl. 7, figs. 1-3.
Schwagerina yabei Beede & Kniker, 1924, Univ. Texas Bull. 2433, p. 24-27, pl. 4, fig. 7; pl. 7, figs. 4-5.
Schwagerina yabei Silvestri, 1933, Mem. dell'Inst. Geol. della R. Univ. di Padova, v. 10, p. 27-29, pl. 1, figs. 1-5; pl. 3, figs. 1-2.
Paraschwagerina yabei Dunbar & Skinner, 1936, Jour. Paleontology, v. 10, p. 89.
Rugososchwagerina yabei Miklukho-Maklay, 1959, Uchenye Zapiski Leningrad. Gosud. Univ., no. 268, ser. Geol. Nauk, no. 10, p. 160.

Shell large, subspherical, with slightly extended poles. Mature shells have 8.5 to 9.5 whorls, and measure 9.00 to 11.86 mm. in length and 7.90 to 9.57 mm. in diameter. First 4 to 4.5 volutions constitute tightly coiled juvenarium which is followed by abrupt inflation into loosely coiled adult stage. In fully grown individuals final volution is somewhat reduced in height, representing gerontic stage. Form ratio at maturity varies from 1.13 to 1.33.

Spirotheca composed of tectum and rather coarsely alveolar keriotheca. It is quite thin in juvenarium and in first whorls of adult stage, but thickens rather abruptly in later volutions. Its thickness measures 43 to 58 μ in 4th whorl, 30 to 37 microns in 5th, 30 to 45 microns in 6th, 58 to 84 microns in 7th, and 109 to 147 microns in 8th. In juvenarium spirotheca is slightly "rugose," but this character does not persist into adult stage. In juvenarium septa are intensely fluted, and septal folds commonly reaching to tops of chambers. In inflated part of shell septal folding, while strong and regular, is restricted to lower part of septa (Pl. 15, figs. *1-2*). Septa number 9 or 10 in 1st whorl, 13 or 14 in 2nd, 13 to 19 in 3rd, 22 or 23 in 4th, 16 to 18 in 5th, 20 to 29 in 6th, 25 to 36 in 7th, 32 or 33 in 8th, and about 45 in 9th. Abrupt decrease in 5th volution marks sudden expansion from juvenarium to adult stage and accompanying wider spacing of septa.

Proloculus very small, its outside diameter ranging from 65 to 127 μ, averaging about 100 μ. Tunnel low and narrow. In 8th whorl tunnel angle measures 15 to 17 degrees. Weak chomata present in juvenarium and may continue into early whorls of adult stage. They are never conspicuous.

Discussion.—Von Staff (1909) originally described this species as *Schwagerina yabei*, and it remained in that genus until Dunbar & Skinner (1936) transferred it to their newly established genus *Paraschwagerina*. Finally, Miklukho-Maklay (1959) designated it as the type species of his newly erected genus *Rugososchwagerina*. Presumably, this generic name is based on the "rugosity" of the spirotheca in the juvenarium. *R. yabei* is reported to be the most common species in the Sosio Limestone, Silvestri (1933) having cited its presence in all four blocks. Our experience, however, indicates that it occurs only in "pockets" in the reef-core facies. We found no specimens in the material collected by Dainelli, although the reef core facies is represented in his collections.

Occurrence.—As mentioned above, this species has been cited from all four known exposures of the Sosio Limestone. In our collections, however, it is represented by several loose specimens, constituting collection S-1, which supposedly came from the Rupe del Passo di Burgio and which were sent to us by Dr. Carl O. Dunbar. In addition, we have two specimens from collection S-6 and several from collection S-5, from the Pietra di Salomone. In collection S-5, where it is fairly common, it is associated with *Yangchienia thompsoni* Skinner & Wilde, n. sp., *Chusenella (Sosioella) sosioensis* Pasini, *C. (S.) glenisteri* Skinner & Wilde, n. sp., *C. (S.) intermedia* Skinner & Wilde, n. sp., and *Pseudofusulina anachrona* Skinner & Wilde, n. sp.

Illustrations.—Plate 15, figures *1-2*; Plate 16, figures *1-4*; Plate 17, figures *1-2*.——Pl. 15, figs. *1-2*. Axial sections of topotypes, ×10. [*1* from collection S-1; *2* from collection S-6.]——Pl. 16, figs. *1-2*. Axial sections of topotypes, ×10.——Pl. 16, fig. *3*. Sagittal section of topotype, ×10.——Pl. 16, fig. *4*. Part of specimen shown in Pl. 15, fig. *2*, ×40. [*1* from collection S-5; *2* from collection S-1; *3-4* from collection S-6.]——Pl. 17, figs. *1-2*. Sagittal sections of topotypes, ×10.

[Both from collection S-5.] [All figures are unretouched photographs.]

Genus VERBEEKINA von Staff, 1909

VERBEEKINA FURNISHI Skinner & Wilde, n. sp.

Verbeekina verbeeki Silvestri, 1933, Mem. dell'Inst. Geol. della R. Univ. Padova, v. 10, p. 34, 35, pl. 1, figs. 10-12; pl. 3, figs. 3-5.

Shell small, subglobular, slightly umbilicate. Mature individuals have 13 to 14 volutions first 6 of which constitute tightly coiled juvenarium which is staffelloid in shape, axis of coiling being shorter diameter. This is followed by more loosely coiled adult stage in which axis of coiling is greater diameter. Such specimens measure about 5.85 mm. in length and about 5.70 mm. in diameter. Form ratio of mature individuals is very constant at 1.02 to 1.03.

Spirotheca composed of tectum and finely alveolar keriotheca. It thickens slowly to end of juvenarium, is sharply reduced at beginning of adult stage, and then slowly thickens through growth of outer whorls. Its thickness is 10 to 14 μ in 3rd whorl, 27 to 32 μ in 6th, 14 to 22 μ in 7th, 32 to 35 μ in 9th, and 55 to 69 μ in 12th. Septa plane throughout shell. Septal count for our only sagittal section is 8, 13, 17, 16, 17, 14, 11, 14, 12, 15, 25, 27 from 1st to 12th volution. Reduction in number at end of 6th whorl marks beginning of more loosely coiled adult stage in which septa become more widely spaced. Marked increase at beginning of 11th volution indicates closer septal spacing of gerontic stage.

Proloculus minute, its outside diameter measuring 40 to 58 μ. Row of low, elliptical foramina present along basal margin of each septum from pole to pole from 3rd whorl outward. Adjacent foramina are separated by low, narrow parachomata. In juvenarium, where septa are closely spaced, parachomata form continuous ridges, but in adult stage they are developed for only short distance on either side of their intersections with septa. They tend to die out in middle of each chamber between septa, so as to form discontinuous ridges from 7th volution outward. For this reason, in axial sections parachomata are always conspicuous in juvenarium. In adult stage, where septa are widely spaced, parachomata are evident only when plane of section passes near a septum. Finally, in gerontic stage with its closer septal spacing, they again become conspicuous.

Discussion.—Silvestri (1933) described and figured this species as *Verbeekina verbeeki* (Geinitz). It differs from that species in its smaller size for a given number of whorls, fewer volutions, thicker spirotheca, more conspicuous parachomata, and slightly larger form ratio. A topotype specimen of *V. verbeeki* is shown for comparison (Pl. 17, fig. *6*). Since this specimen has the same number of whorls as the example of *V. furnishi* (Pl. 17, fig. *3*), a direct comparison can be made. It should be noted that the specimen of *V. verbeeki* is not a fully grown individual; at maturity such shells have about 17 volutions. This species is named for Dr. W. M. Furnish.

Occurrence.—*Verbeekina furnishi* is a rare species. We have only four specimens from collection S-7, from the Pietra di Salomone, where it is associated with *Schwagerina dainellii* Skinner & Wilde, n. sp., and *Neoschwagerina sosioensis* Skinner & Wilde, n. sp.

Illustrations.—Plate 17, figures *3-5*; Plate 18, figures *1-4*.——Pl. 17, fig. *3*. Axial section of holotype, ×10.——Pl. 17, figs. *4-5*. Axial sections of paratypes, ×10.——Pl. 18, figs. *1-2*. Sagittal section of a paratype, ×10 and ×20, respectively. ——Pl. 18, fig. *3*. Part of holotype, ×20.——Pl. 18, fig. *4*. Part of specimen shown in Pl. 17, fig. *5*, ×40. [All from collection S-7.] [All figures are unretouched photographs.]

Illustration for comparison.—Plate 17, figure *6*. Axial section of topotype of *Verbeekina verbeeki* (Geinitz), ×10. This specimen has the same number of whorls as the one shown in Pl. 17, fig. *3*. [From Padang District, Sumatra.]

Genus NEOSCHWAGERINA Yabe, 1903

NEOSCHWAGERINA SOSIOENSIS Skinner & Wilde, n. sp.

Neoschwagerina craticulifera Silvestri, 1933, Mem. dell' Inst. Geol. della R. Univ. Padova, v. 10, p. 36, 37, pl. 1, figs. 13-14; pl. 2, fig. 8; pl. 3, fig. 7.

Shell small, inflated fusiform, with bluntly rounded poles. Mature specimens have 17 to 19.5 whorls, rarely 20, first 2 of which are commonly coiled askew to later ones. Such individuals measure 5.84 to 6.83 mm. in length and 3.95 to 5.12 mm. in diameter. Average length is 6.33 mm.

and average diameter 4.40 mm. Form ratio varies from 1.26 to 1.73, averaging 1.45.

Spirotheca composed of tectum and finely alveolar keriotheca. In 15th volution its thickness varies from 25 to 43 μ, averaging 38 μ. Septa essentially plane and rather widely spaced, their spacing increasing progressively in such manner that increase in number from whorl to whorl is small. They number about 4 in 1st whorl, 11 in 2nd, 8 to 11 in 3rd, 11 to 15 in 4th, 12 to 13 in 5th, 12 to 15 in 6th, 15 to 16 in 7th, 15 to 19 in 8th, 14 to 20 in 9th, 18 to 19 in 10th, 18 to 19 in 11th, 21 to 22 in 12th, 21 to 25 in 13th, 20 to 23 in 14th, 22 to 25 in 15th, about 27 in 16th, and about 25 in 17th. Axial septula, consisting of ribbon-like prolongations of keriotheca, first appear in 4th volution. Maximum number per chamber is 1 in 4th, 5th, and 6th volutions, 2 in 7th to 11th, and 3 from 12th outward. Rarely there are four in some chambers of outermost whorls.

Proloculus minute, its outside diameter varying from 42 to 105 μ, averaging 66 μ. Row of low, rounded to elliptical foramina present along basal margin of each septum from pole to pole. Adjacent foramina separated by low, narrow parachomata. Latter number 1 in 1st whorl, 3 in 2nd, 3 to 8 in 3rd, 6 to 9 in 4th, 8 to 13 in 5th, 10 to 18 in 6th, 11 to 21 in 7th, 13 to 24 in 8th, 16 to 28 in 9th, 22 to 33 in 10th, 24 to 36 in 11th, 28 to 39 in 12th, 30 to 45 in 13th, 35 to 45 in 14th, 39 to 46 in 15th, 43 to 50 in 16th, 45 to 50 in 17th, and 47 to 52 in 18th.

Primary transverse septulum, formed in same manner as axial septula, is positioned immediately above each parachoma, and basal margins of transverse septula are joined to tops of parachomata to form partitions which subdivide meridional chambers into rectangular chamberlets. Small, rounded to elliptical lateral foramina pierce these partitions to provide lateral communication within shell. Ordinarily, these foramina are located just behind and just in front of each septum. Incipient secondary transverse septula may be present in outer whorls, but they are very short, few in number, and inconsistent in their occurrence.

Discussion.—Silvestri (1933) described and figured this species as *Neoschwagerina craticulifera* (Schwager). The Sosio specimens, however, differ from that species in their more numerous axial septula, larger size, less numerous septa, and less numerous parachomata.

Occurrence.—We have found *Neoschwagerina sosioensis* only in collections S-3 and S-7 from the Pietra di Salomone. Silvestri, however, cited it as occurring in the Rocca di San Benedetto, also.

Illustrations.—Plate 19, figures *1-8*; Plate 20, figures *1-2*.——Pl. 19, fig. *1*. Axial section of holotype, ×10.——Pl. 19, figs. *2-5*. Axial sections of paratypes, ×10.——Pl. 19, figs. *6-8*. Sagittal sections of paratypes, ×10. [*1-4, 7-8* from collection S-7; *5-6* from collection S-3.]——Pl. 20, fig. *1*. Axial section of the holotype, ×20.——Pl. 20, fig. *2*. Specimen shown in Pl. 19, fig. *6*, ×20. [*1* from collection S-7; *2* from collection S-3.] [All figures are unretouched photographs.]

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